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THE KANSAS CITY FLOOD OF 1903.

The flood which swept down the valley of the Kaw River three months ago and wrought destruction at Topeka, Kansas City and other towns along its course will rank as one of the greatest disasters in respect to property loss that has ever visited this country. Particularly notable from an engineering point of view was the damage done to bridges at Kansas City and the interruption to traffic thereby caused, the effect of which on food supplies was felt over a vast area. It is only when some such great calamity stops the course of commerce at some point that the public realizes how absolute a necessity modern systems of transportation and communication have become.

At our request, Messrs. Waddell & Hedrick, of Kansas City, have furnished to us a statement of the principal results of the flood and the features of engineering interest in connection therewith, which we print below, together with photographs illustrating some of the flood's work:

For several days during the latter part of May very heavy rains fell in the central Missouri valley, extending over almost the entire area of Kansas, Missouri, and Nebraska. All of the large streams were very much higher than usual, but no very serious damage was done to property in the Missouri or the Kaw River valleys.

On Friday, May 29, the Kaw River at Kansas City began to rise very rapidly, and by Saturday evening the water began to come up in the streets in Armourdale and that portion of Kansas City, Kan., located in the Kaw River bottoms. The river continued to rise throughout the night and on Sunday morning the water had almost crossed the bottoms and was within a short distance of the Union Depot. It then became evident that if the river continued to rise great damage would be done. All traffic on the surface street car lines was stopped. The river continued to rise all day Sunday. Many buildings in the low lands were picked up and carried away by the current. The surface of the river was covered with all kinds of floating debris.

By four o'clock in the afternoon the river had risen to the level of the roadways on most of the bridges, and in many cases was flowing over them. All railway structures were loaded down with cars or engines. By six o'clock the water was in some cases flowing over the tops of flat cars standing on the bridges. The drift had accumulated above these structures in enormous quantities, and they were under almost breaking strain to withstand it. It required only a small additional force to destroy them. Finally a large oil tank floated into the current and was carried against the already tottering structures.

There were sixteen bridges carried away within two hours' time between Argentine and the mouth of the Kaw, a distance of only four miles. Only one bridge across the Kaw River near Kansas City remained, that of the Missouri Pacific Ry. Co., a very heavy double-track structure, which was loaded from end to end with locomotives.

FIG. 1. MISSOURI PACIFIC R. R. BRIDGE OVER THE KAW RIVER AT KANSAS CITY DURING THE FLOOD OF MAY 31, 1903.

Beginning at the mouth of the Kaw River the following is a list and partial description of the bridges across it before the flood:

1. The Wyandotte & Northwestern Ry. Bridge.—This structure consisted of three combination wood and iron spans of about 200 ft. each, resting on steel cylinder piers. The entire superstructure was destroyed, and the channel piers were overturned. The cost of repairing this structure will be about $180,000.

2. The "Flow Line" Bridge.—This structure carried the water supply for Kansas City, Mo., and a portion of Kansas City, Kan., over the Kaw River. The superstructure consisted of two steel spans of 185 ft. and 226 ft., respectively. These spans rested on masonry abutments and one central cylinder pier. The 185-ft. span was destroyed and the 226-ft. span badly injured. None of the foundations were injured.

As a result of the destruction of this bridge the entire city was without water for twelve days. The power houses of the Street Railway company, the Electric Light company and the Gas company were all shut down because of lack of water. Thus for a period of twelve days Kansas City, Mo., had no water, no street car service and no electric or gas lights, and all on account of the destruction of one 185-ft. bridge span. The loss to the city by the destruction of this bridge cannot be estimated.

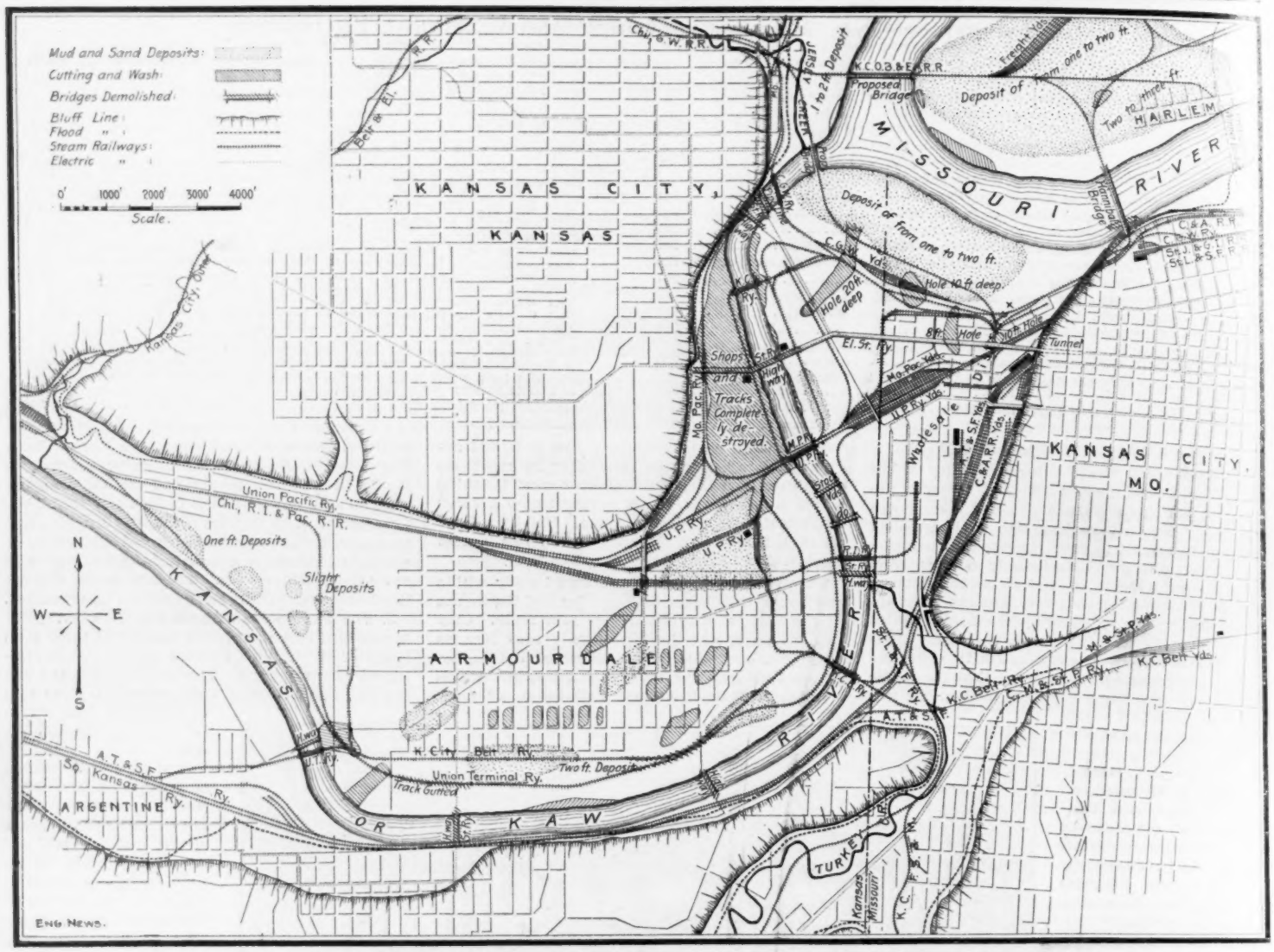
3. The Metropolitan Street Ry. Co.'s Bridge at James St.—This structure consisted of three steel spans of 170 ft. each and one of 120 ft.—all resting on masonry piers. The three river spans and the two channel piers were destroyed. The cost of replacing this structure will be about $150,000.

4. The James Street Highway Bridge.—This structure consisted of two 240-ft. steel spans resting on one masonry pier and two masonry abutments. Both spans and one abutment were destroyed. This structure will be rebuilt in connection with the Metropolitan Street Ry. Co.'s bridge, and its cost is included with that bridge.

5. The Kansas City Southern Ry. Co.'s Bridge at Ohio Ave.—This structure consisted of three steel spans of 197 ft. each, resting on concrete piers. The spans were all lifted from the piers and carried down stream from 350 ft. to 700 ft. They are new and of the riveted type, and are apparently in almost as good condition as when completed. The piers were not damaged. The spans will be replaced on the piers without cutting them apart. The cost of repairing this structure will be about $45,000.

6. Combined Highway and Electric Railway Bridge at Central Ave.—This structure consisted of three 198-ft. pin-connected steel spans, resting on masonry piers. The spans were double decked. The lower deck carried a highway 20 ft. wide and a 7-ft. sidewalk, the upper deck two street railway tracks. The three spans and two of the piers were destroyed. Some of the metal will be recovered and used in the new structure. Approaching this bridge was an elevated railway structure and about 600 ft. of this was torn down. The cost of rebuilding this structure will be about $100,000.

7. The Missouri Pacific Railway Co.'s Bridge.—This structure consisted of three double-track steel spans of about 200 ft. each, resting on masonry piers. These spans were uninjured. The



MAP OF KANSAS CITY, SHOWING THE AREA FLOODED AND DESTRUCTION DONE BY THE FLOOD OF MAY 31, 1903.

fact that these spans stood may be accounted for as follows:

The structure is a very heavy one, designed for modern loads, and is double tracked, giving it great lateral stability; it was not struck by the heavy oil tank which played such havoc with the bridges farther down stream; the current at this point in the river was largely diverted to another channel, and the bridge was loaded down with heavy locomotives. This bridge furnished the railways for several weeks the only means of crossing the Kaw River.

8. Union Pacific Ry. Co.'s Bridge.—This structure consisted of three double-tracked pin-connected steel spans, resting on masonry piers and abutments. The spans were all destroyed but the piers were not badly damaged. This structure was rather old and of light design. The cost of rebuilding will be about $200,000.

9. Stock Yards Company's Bridge.—This structure consisted of three riveted steel spans, resting on masonry piers. The spans were all town down, but they were not badly damaged and the greater portion of the metal will be used in the new structure. The piers were badly damaged, as they were constructed of a very soft sandstone. The cost of replacing this bridge will be about $60,000.

10. The Upper Stock Yard Bridge.—This structure was composed of three light pin-connected steel spans of about 200 ft. in length, two masonry piers and two masonry abutments. The spans were all totally destroyed. The cost of rebuilding will be about $40,000.

11. Chicago, Rock Island & Pacific Ry. Co.'s Bridge.—This structure consisted of three single-

FIG. 2. MISSOURI PACIFIC R. R. BRIDGE AT PRESENT.

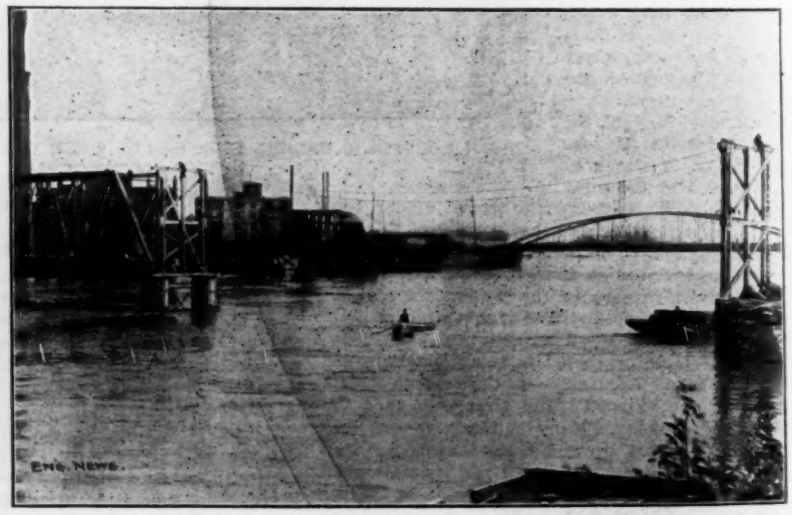


FIG. 3. "FLOW LINE" BRIDGE IN FOREGROUND, STANDING SPAN OF JAMES ST. BRIDGE IN REAR.

track riveted spans, each about 200 ft. long, resting on masonry piers. The spans were all taken from the piers but were not badly injured. These spans might be replaced on the piers if they were heavy enough for the present traffic. The piers were badly damaged and will have to be replaced. The cost of rebuilding will be about $120,000.

12. Kansas Avenue Highway and Electric Railway Bridge.—This structure provided for a 20-ft. roadway, a sidewalk, and two street railway tracks. The three spans, each about 200 ft. long, were of the combination wood and iron type. They were all entirely destroyed. The piers were not badly damaged and may be used in the new structure. Cost of rebuilding, about $75,000.

13. Kansas City Belt Ry. Co.'s Bridge.—This structure consisted of three single-track combination wood and iron spans, resting on masonry piers. These spans were all destroyed, but the piers were not damaged. The cost of a new superstructure for this bridge will be about $80,000.

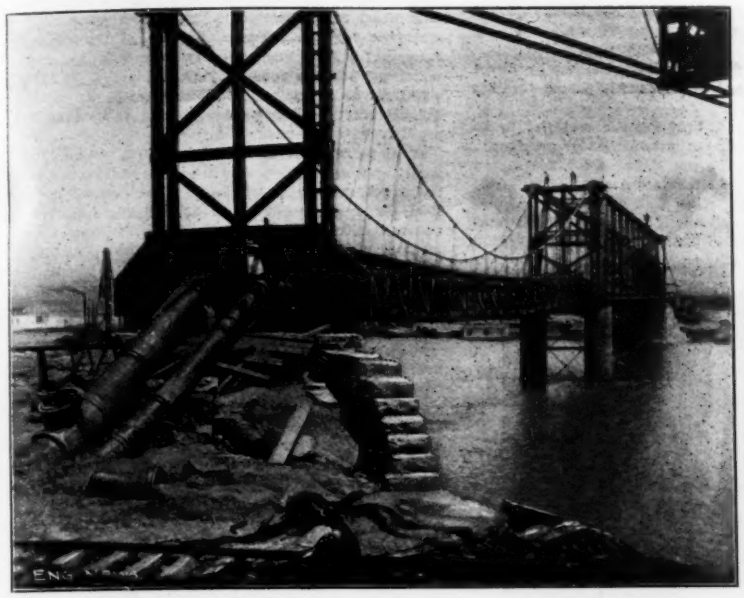


FIG. 4. "FLOW LINE" BRIDGE AS REPAIRED WITH SUSPENDED SPAN AFTER FLOOD.

14. Fifth St. Highway Bridge.—This structure was a light highway bridge. The spans were of steel and of the pin-connected type. They were all destroyed. The piers and abutments are all in good condition. The spans were knocked down by driftwood. Cost of rebuilding, about $35,000.

15. Twelfth St. Bridge.—This structure was a combined highway and electric railway bridge. The spans were of steel and of the pin-connected type. All spans but one were destroyed. The piers were of masonry. The two end piers and the east abutment are in good condition, the two middle piers considerably damaged, and the west abutment destroyed. The spans were thrown down by floating debris. Cost of rebuilding, about $45,000.

16. Kansas City Southern Ry. Co.'s Bridge in Argentine.—This structure was a single-track railway bridge of four pin-connected steel spans resting on steel cylinder piers. The spans were all knocked down except the west one. The piers are all standing, but one of the channel piers is slightly out of position. Some of the old spans are in fairly good condition and a portion of the metal might be used again. The spans fell when struck by the highway bridge just above. The cost of replacing this structure will be about $100,000.

17. The Old Southern Bridge.—This structure was a highway bridge, and was perhaps the oldest bridge over the Kaw River near Kansas City. There were four spans resting on masonry piers. The spans were all destroyed. The piers were not badly damaged, and by repairing can be used in the new structure. The cost of rebuilding will be about $45,000. The spans went down from being struck by floating houses and heavy drift.

The total cost of rebuilding all of the bridges over the Kaw destroyed by the flood will be from $1,250,000 to $1,500,000.

A study of the condition of the various wrecked structures shows very conclusively the greater durability of solid riveted spans when compared with those of the pin-connected type. Of the sixteen bridges destroyed, three were riveted structures, viz.: The Kansas City Southern Railway Company's Bridge at Ohio Avenue, the Stock Yards Company's lower bridge, and the Chicago, Rock Island & Pacific Ry. Co.'s bridge. All of these structures were knocked down, but in all three cases the spans are but little damaged and may be used again. But little is worth recovering of the metal in the pin-connected spans.

The only set of solid concrete piers in the river were those of the Kansas City Southern Ry. Co.'s bridge at Ohio Ave. These piers were located near the mouth of the river, where they were struck by all the heavy debris, but they were practically uninjured.

FIG. 8. KANSAS CITY SUBURBAN BELT R. R. BRIDGE, SHOWING CONCRETE PIERS INTACT.

FIG. 5. TWELFTH ST. BRIDGE, ARGENTINE, KAN., SHOWING INJURY TO DOWN-STREAM SIDE OF RIVER PIERS.

FIG. 6. KANSAS CITY SOUTHERN R. R. BRIDGE, ARGENTINE, KAN., SHOWING CONDITION OF CYLINDER PIERS.

To guard against a future disaster of this kind, all new bridges over the Kaw should be raised high enough to clear the recent high water level by from 8 to 10 ft. The spans should be made longer so that not more than one pier would be placed in the channel.

By combining two or more bridges into one and making these combined bridges very wide and

heavy, and with very rigid lateral bracing, there would be very much less liability to failure.

Concrete piers of proper dimensions will withstand without injury any such floods.

The actual damage done to the bridges represents only a portion of the loss the cities suffered from their destruction, as the loss from the lack of transportation facilities has no doubt been equally great. The railways terminals are nearly all located in the river bottoms and some of the principal freight yards were practically destroyed. The handling of freight has been and still is a very difficult matter. The loss to the various railway companies from damage done to their tracks, yards and rolling stock has been enormous. The total loss within the two Kansas cities in buildings, merchandise, bridges, railway improvements, industries and loss of business, etc., has no doubt exceeded $10,000,000.

The view of the Missouri Pacific bridge on page 233 conveys an idea of the great amount of drift which the bridges had to withstand. As this bridge remained standing, the drift was deposited above it. Several millions of feet of lumber was lodged against the bridge.

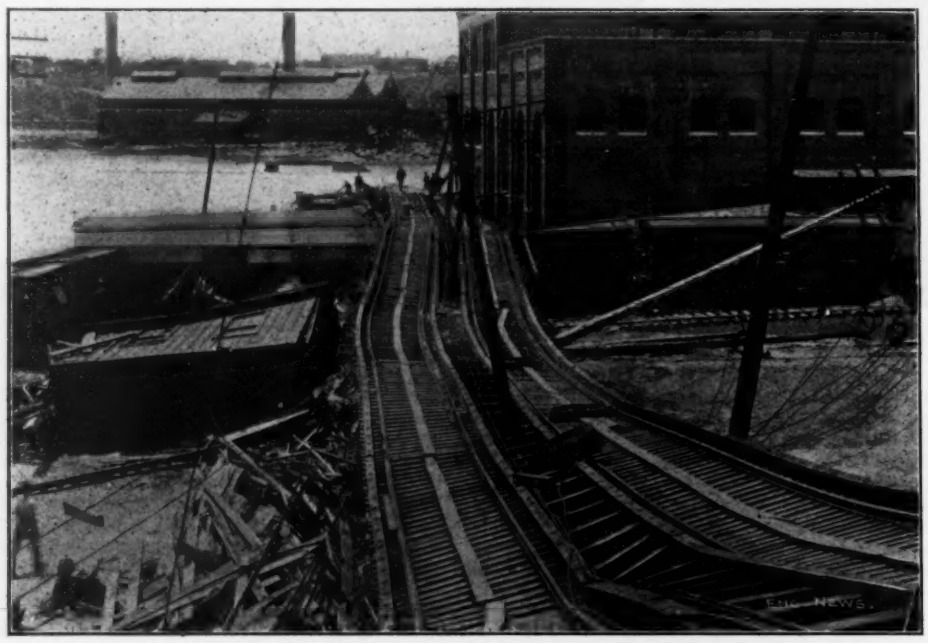


FIG. 7. APPROACH OF ELEVATED RAILWAY LINE OF METROPOLITAN STREET RAILWAY CO. TO CENTRAL AVE. BRIDGE.

The Kaw River near the mouth has been gradually encroached upon for years, the abutting property owners filling in and reclaiming the land for industrial purposes. The normal width of the river from bank to bank is about 800 ft. At the James St. bridge, just above the mouth, this channel had been narrowed down to about 450 ft. between abutments. The effect of this contraction was shown by the fact that the high water mark at the Turkey Creek pumping station, about two miles above the mouth of the river, was 10 ft. above that at the mouth. If the river had been given its natural width through the city, the water would not have risen so high by from 6 to 8 ft. in the upper districts as it did under the existing conditions. It is evident that the clear channel of the Kaw should be made from 800 to 1,000 ft. wide from Argentine to the Missouri Rived.

It would be practicable to protect against all future floods the low lying lands through the cities by building about eleven miles of good, strong levees along the banks, and widening the channel as suggested above.

The property damages in connection with such a protection work would be great of course, but not in comparison to the losses caused by the last flood.

No bridges over the Missouri were destroyed near the city, but the approaches to the Chicago, Milwaukee & St. Paul Ry. bridge at Randolph, five miles below, and of the Atchison, Topeka & Santa Fe Ry. bridge at Sibley, 27 miles below Kansas City, were both partially washed out.

THE MECHANICAL DRYING OF MINERALS *

By C. O. Bartlett.†

There are three systems of drying minerals mechanically, as follows:

(1) By direct heat: by this is generally meant the use of the rotary dryer, or a horizontal cylinder, set in brickwork with front and grates similar to a horizontal boiler. The cylinder is set on an incline and revolves very slowly, from five to eight revolutions a minute. The material to be dried is fed into the cylinder at the front end, and at each revolution of the cylinder is carried forward towards the discharge end of the dryer, being continually picked up by interior elevators and cascaded while passing through the cylinder.

(2) By air, which has first been heated either by direct heat or by steam pipes, and is afterwards passed through the material to be dried.

(3) By direct steam heat, bringing the material to be dried in direct contact with the steam cylinder or pipes.

The first method is by far the cheapest for the reason that by using direct heat a temperature of 2,500 to 3,000° can be had, while in using heated air the temperature is very much less; and in using direct steam heat the temperature is only from 230 to 330°. By first superheating the steam the temperature can be made much higher, but the cost of superheating the steam will nearly or quite counterbalance all gain in temperature.

Great care should be taken in the construction and erection of all direct-heat dryers. All iron parts should be so constructed as to allow for contraction and expansion, otherwise they will soon break. All settings and bearings for the dryer should be extremely substantial on account of the liability to get out of place by the settling of the brickwork and by the extreme heat.

The steel sheets of the cylinder should run the entire length, and all seams should be longitudinal. There should be no cross seams at all, for they are liable to break. In building steam dryers, great care must be taken with every joint or rivet, otherwise the contraction and expansion will soon cause leakage.

In drying minerals, they should first be crushed into 2-in. cubes or smaller. It is difficult to dry anything in a body; it is necessary to have as large heating surface as possible, and to keep the material being dried constantly in motion, cascading it through the heat and dropping it on hot surfaces.

The cost of drying minerals depends upon five factors, as follows:

(1) Upon the amount of water or moisture contained therein. Concentrates, ores or silica materials will not carry more than 10 or 12% moisture, while clays and marls will carry two to three times as much, and peat will sometimes have as much as 80% moisture.

It is generally safe to estimate on evaporating 10 lbs. of water for 1 lb. of coal used, or its equivalent, when drying concentrates, ores, limestones, and other similar products, where the products of the fire can pass through the material to be dried.

It will not pay to dry material containing 80% moisture, unless it is very valuable. For example, we may take 100 tons of peat, containing 80% moisture, and reduce it to 5%, which means evaporating 75 tons of water, leaving 25 tons of dried peat. It will take 1 lb. of coal, or its equivalent for fuel, to evaporate 10 lbs. of moisture, which means no less than 15,000 lbs. of coal for fuel to obtain 25 tons of dried peat. Moreover, it is difficult in drying peat to evaporate as high as 10 lbs. of moisture with 1 lb. of coal for the reason that after peat is nearly dry it becomes somewhat combustible and requires slow firing, otherwise it will take fire.

It is better to store peat in large sheds, or even out of doors where it will drain and dry by the wind and sun, down to 40% moisture, after which it can be profitably dried on mechanical dryers. It is quite a different matter to dry 100 tons of concentrates, ores, or silica substances, for here we have only from 8 to 10% moisture, which we wish to reduce by three-fourths, which means about six or seven tons of moisture to be evaporated, requiring only about 1,500 lbs. of coal, or its equivalent to dry it.

(2) Upon whether or not the material to be dried will admit of passing the products of the fire through the material without injury. In other words, it will be readily seen that better results can be obtained from the same amount of fuel by first passing the heat around the outside of the drying cylinder and then through the material. By this means the temperature of the gases passing off the dryer can be brought down to 125° F., which, of course, means that nearly the entire heat of the coal or its equivalent is utilized.

Most minerals, such as concentrates, ores and clays, are not injured by passing the products of combustion through them. Some fine clays and even some kinds of sand used for glassware will not admit of it on account of the danger of discoloration by the fire products. In all such cases it is necessary to use oil or gas for fuel, or to keep the products of combustion on the outside only.

(3) Upon whether or not the material to be dried is of a silica or of a clayey nature. From silica the moisture is easily driven off, but from clay it is more difficult to evaporate the moisture, besides, the sticky material is liable to adhere to parts of the dryer, causing trouble.

(4) Upon whether the material is of an explosive nature, or whether there is danger of burning it, as with coal, peat and similar materials. If so, the temperature must be kept low. There is no danger of burning any material containing a considerable amount of moisture, and in drying some materials it is sometimes well to use two dryers, firing heavy on the first dryer while there is plenty of moisture, and finishing on another dryer with light firing.

(5) Upon whether it is necessary to dry to a very low degree of moisture. It is much harder and more expensive to dry down to ½% than to 2%. Generally speaking, however, it is not necessary to go below from 2 to 5% on most materials.

DRYING COAL.—In drying coal the object is to drive off the moisture without losing any of the volatile gases or the fine particles. The use of rotary kilns for roasting ores and for burning Portland cement has of late years increased very rapidly, and the use of powdered coal in annealing furnaces and in a pulverized state under boilers has caused a rapidly increasing demand for pulverized coal. I fully believe that in all large and medium-sized plants the power will be supplied with coal dust burned in a manner similar to gas and that this is the only way to get perfect combustion.

Coal to be satisfactorily and economically pulverized should first be thoroughly dry. To get the best results from grinding machinery there should not be more than 1% of moisture in the coal. The grinding capacity of mills is nearly double on coal with 1% moisture to what it is with moisture of 2%. We rarely find two lots of coal which will dry alike. Some coal will give up its moisture easily and freely, and other grades will apparently grow wetter as they grow hotter. Within the past six months we have been called upon to dry, in one case, coal from which we could remove 8% of moisture at the rate of 15 tons per hour, and other coal from which it was impossible to remove more than 6% at the rate of eight tons per hour. We have seen coal which has laid under cover for two months, develop from 6% to 8% moisture on being heated and put into the storage bins, and have seen water run in a stream from the hopper.

From the best determinations we have been able to make it seems that the coal in which the ash is composed largely of silica will give up its moisture easily and thoroughly while that in which the ash is high in lime or clay is very difficult to dry, and the moisture really has to be sweated out.

It is very important that coal be handled in such way that warm air in large quantities can be brought in contact with every particle of it, so as to absorb the moisture and carry it off as fast as it is released. This is best accomplished by passing the currents of air from the dried material through that which is wet. Furthermore, the currents of air should be subject to regulation in order that the heat will not become so intense as to release any of the volatile matter.

There is always a certain amount of risk in handling coal, both in drying and pulverizing, but this can be reduced to a minimum by using the proper precautions.

*Condensed from a paper read at the American Mining Congress at the meeting at Deadwood, S. D.

†President, C. O. Bartlett & Snow Co., Cleveland, O.

One notable disaster in the East during the past year cost the lives of seven men, besides a large property loss. Do not use a machine in which particles can get caught, for they are liable to ignite if held in contact with a heated surface for any length of time. Do not use a dryer whose rated capacity is just enough to supply your needs.

It is never safe to pass the products of combustion through the drying coal. With some coal it might be done, and in fact has been done with coal of 54% volatility. It is best, however, to stay on the safe side and not sacrifice safety for efficiency.

It is generally safe in drying coal to estimate on evaporating from six to eight pounds of moisture to one pound of coal, or its equivalent used for fuel.

It is difficult to tell at just what temperature coal will begin to give off gas, and indeed this point varies with different coal, but it is generally safe to say that coal can be delivered from the dryer at about 150° F. without loss of gas. We have been asked to discharge at 225°, and have found that this can be done, but not without loss of a small percentage of gas, and this cannot be recommended as good practice.

It is necessary to use a fan-blast to get sufficient air to carry off the moisture, and this will carry the dust produced by crushing with it. This dust amounts to from 3 to 5% of the total amount of coal and is worth saving. This is accomplished by placing the fan-blast above the receiving hopper, using suction on the cylinder and forcing the dust and moisture into a settling chamber made of non-conducting material, preferably brick. The wall of this chamber will retain sufficient heat to prevent the moisture from condensing, and should be large enough to allow the dust to settle. The bottom of the settling chamber should slant at least 45° to the center, which will cause the dust to slide to the middle, where it can be carried off either by screw or chain conveyor.

A FAST TRANSCONTINENTAL JOURNEY.

In our issue of Aug. 20 we gave a summary of the rapid trip across the continent from New York to Los Angeles, made by Mr. H. P. Lowe in the endeavor to reach his sick daughter before her death. It will be a matter of interest to record here some further particulars of this trip, which unfortunately did not accomplish its purpose.

The first part of the journey was made on the regular "20th Century Limited" (or 20-hour train) over the New York Central R. R. and Lake Shore & Michigan Southern Ry. from New York to Chicago. At Chicago a transfer was necessary, and 32 minutes elapsed between Mr. Lowe's arrival on the "Limited" at the La Salle St. Station and his departure from the Polk St. Station on a special train over the Atchison, Topeka & Santa Fe Ry. This latter train made a straight run to Los Angeles. The total time consumed in the journey was 73 hours 21 minutes: New York, 2.45 p. m. Aug. 4, and Los Angeles 1.06 p. m. Aug. 7, with three hours allowed for changes of time. The stops on the New York Central R. R. (including Buffalo) aggregated about 30 minutes; on the Lake Shore & Michigan Southern Ry. they aggregated 52 minutes (according to the official record). On the long run west of Chicago they aggregated about an hour. These stops, and the 32 minutes for transfer at Chicago, amount to 2 hours 54 minutes. The actual running time of the trains is therefore reduced to 70 hours 27 minutes, or say 70.5 hours for a total distance of 3,215 miles. This gives an average running speed of 45.6 miles per hour.

The New York Central Ry. has furnished us with a copy of the train sheet of the 20th Century Limited for Aug. 4, and particulars of the train, stating that it consisted of five cars—three Pullman sleeping cars, 123,000 lbs. each; a dining car, 127,500 lbs., and a L. S. & M. S. Ry. buffet car, 108,750 lbs. Three engines were used, all of the Atlantic type; each weighed 176,000 lbs., and had a tender weighing 114,000 lbs. From New York to Buffalo the train was on schedule time in passing most of the stations, and made all stops on schedule time, reaching Buffalo at 11.42 p. m. There were no extra stops. Over the Lake Shore & Michigan Southern Ry. the train was composed of three sleeping cars and a buffet car, with a dining car in addition for certain parts of the run. To Mr. W. H. Marshall, General Superintendent of the Lake Shore & Michigan Southern Ry., we are indebted for particulars of the train and for a copy of the train sheet, showing the times of passing all stations. This train sheet is summarized in the table below. It will be noted that the speeds between stops are not especially high, but of course these average speeds were very much exceeded at various points. The times and distances on the train sheet indicate speeds of over 80 miles an hour; the exact speeds cannot be stated as the times are given only to the nearest minute, no seconds being recorded.

From Buffalo to Elkhart, the train was made up of three sleeping cars and a buffet car, its weight being 470,000 lbs. From Elkhart to Chicago there was also a dining car, bringing the weight up to 590,000 lbs. The engines used were as follows:

	Buffalo to Cleveland.	Cleveland to Toledo.	Toledo to Chicago.
Type	Prairie (2-6-2)	10-whl. (4-6-0)	10-whl. (4-6-0)
Cylinders	20½ × 28 ins.	18 × 24 ins.	20 × 28 ins.
Driv. whls.	6 ft. 8 ins.	5 ft. 8 ins.	6 ft. 8 ins.
Weight: Eng-tendr	290,000 lbs.	210,300 lbs.	297,000 lbs.

The special train on the Atchison, Topeka & Santa Fe Ry. consisted of an engine, private car and baggage car. There were 15 engines used on this road. These included six Prairie (or 2-6-2) type engines, with 69-in. and 79-in. driving wheels; three eight-wheel (or 4-4-0) engines, with 69-in. driving wheels; and six ten-wheel (or 4-6-0) engines with 69-in. driving wheels. On this line there are long stretches of heavy mountain work, the road attaining summit elevations of 7,608, 7,422 and 6,949 ft. above sea level.

The accompanying table presents a summary of the entire trip.

TRANSCONTINENTAL RAILWAY TRIP: NEW YORK TO LOS ANGELES.

1. New York to Buffalo; N. Y. Central Ry.

Date.	Stops.	Time of Arrival.	Time of Departure.	Running time hrs.	Running time mins.	Distance bet. stops, miles.	Average speed, mls. pr hr.
Aug. 4.	New York	.....	2:45 p. m.	..	..	.....	..
"	Albany	5:35 p. m.	5:39 "	2	50	143	50
"	Utica	7:29 "	7:31 "	1	50	95	52
"	Syracuse	8:38 "	8:42 "	1	07	53	47½
"	Rochester	10:13 "	10:15 "	1	31	80	53
"	Buffalo	11:42 "	.....	1	05	69	64
	Total	.....	.....	8	23	440	52

2. Buffalo to Chicago; L. S. & M. S. Ry.

Aug. 4.	Buffalo (time changes here)	.....	10:45 p. m.	..	..	...	..
"	Farnham (first extra stop)	11:15 p. m.	11:22 "	0	30	26	52
Aug. 5.	Erie (7 mins. late)*	12:35 a. m.	12:39 a. m.	1	13	62	51
"	Saybrook (second extra stop;†	1:23 "	1:26 "	0	44	46	63
"	Collinwood (third extra stop)	2.10 "	2:13 "	0	44	41½	56
"	Cleveland	2:27 "	2:30 "	0	14	7½	32
"	Brownhelm (fourth extra stop)	3:19 "	3:28 "	0	49	30	37
"	Ceylon (fifth extra stop)	3:45 "	3:53 "	0	17	11	38
"	Sandusky (sixth extra stop)	4:10 "	4:12 "	0	17	13	46
"	Toledo (20 mins. late)	5:05 "	5:07 "	0	53	47½	54
"	Elkhart	7:27 "	7:37 "	2	20	133½	57
"	Englewood	9:27 "	9:28 "	1	50	94½	52
"	Chicago	9.45 "	.....	0	17	6½	23
	Total	.....	.....	10	8	519	51.3

*Due to stop at Farnham; other stops made on time, except Toledo.
†Coal chutes.

3. Chicago to Los Angeles; A., T. & S. F. Ry.

Aug. 5.	Chicago	.....	10:17 a. m.	..	..	...	..
"	Fort Madison	2:57 p. m.	.....	4	40	258	51
"	Kansas City	9:45 "	.....	6	47	222	33
Aug. 6.	Emporia	12:28 a. m.	.....	2	40	126	47
"	Newton	2:05 "	.....	1	35	73	46
"	Dodge City (change of time)	5:32 "	4:34 a. m.	3	25	153	45
"	La Junta	9.08 "	.....	4	34	202	44
"	Raton	11:47 "	.....	2	37	105	40
"	Las Vegas	2:21 p. m.	.....	2	22	111	46
"	Albuquerque	5:46 "	.....	3	23	132	40
"	Gallup	9:20 "	.....	3	32	158	46
Aug. 7.	Winslow	12:01 a. m.	.....	2	39	128	50
"	Seligman (change of time)	4:04 "	3:06 a. m.	4	01	143	36
"	Needles	6:23 "	.....	3	17	149	45½
"	Barstow	9.58 "	.....	3	33	169	47¾
"	Los Angeles	1:06 "	.....	3	06	141	45½
	Total	.....	.....	52	11	2,256*	43

*Actual distance, due to avoiding a cut-off, 2,256 miles; the distance by main line is 2,250 miles.

ANNUAL CONVENTION OF THE NEW ENGLAND WATER-WORKS ASSOCIATION.

The twenty-second annual convention of the association was held at Montreal, Sept. 9 to 11, inclusive. The attendance was unusually large, and many new members were elected.

The first two days were devoted to business and the third day was given over to sightseeing and other forms of pleasure.

THE MONTREAL WATER-WORKS.

The whole of one session was utilized for the presentation of two papers and numerous lantern slides relating to the Montreal water-works. The first of these papers was by Mr. George Janin, superintendent of the works. It was historical and descriptive in character.

Towards the year 1800 water from springs on Mount Royal was distributed in wood pipes. In 1815 water was pumped from the St. Lawrence River, at the city water front, to tanks. In 1845 these early works were bought from a private company. In 1853-4 a new and purer supply was introduced from the Lachine Rapids, above the city, with Mr. T. C. Keefer as engineer. A combined supply and power canal, nearly five miles long, was built, and two breast wheels, working six pumps, were installed to raise water to a reservoir. Since that date the canal has been enlarged and extended, turbines have been substituted for breast wheels, an auxiliary steam plant has been added, and a high level service has been provided. At present a 5,000,000-gallon electrically-driven pump is being installed for the high service. The electric power will be furnished by the company now controlling the three formerly independent power plants in the vicinity of Montreal. The city has the choice of rates of $36 per E. HP. for day or $21 for night service of 12 hours.

SERVICE BOXES.—Following the paper thus briefly abstracted, Mr. T. W. Lesage, assistant superintendent of water-works, described the development of service boxes in Montreal. Tenants are responsible for water rates, and the payment of the latter is enforced by shutting off the water. This makes necessary a stop-cock and service box for each tenant in a building, except in very large tenement or apartment houses, where, by special agreement, the owner guarantees payment. The ground freezes to a depth of from 4 to 6 ft., so besides being numerous the service boxes must be set deep.

The early service boxes were of wood, generally 4 ft. deep. Some 25 years ago, a 1-in. wrought-iron tube, with a telescopic joint, was adapted to lessen the difficulties and dangers incident to boxes being pushed above the sidewalk level by frost. Later, a mechanic employed at the water department shops devised a stop-cock operated pneumatically. A valve was raised or lowered by means of a piston, operated by air forced in, as desired, by small pumps like a bicycle pump. Air connection was made by ⅛-in. brass tubes, one for each side of the piston. These tubes were sometimes acted upon by frost and split, and occasionally a stop-cock would close through the relief of pressure from beneath, due to the sudden emptying or partial emptying of the street main. In general, the setting and adjustment were too fine for such a device as a service box.

The next plan was a return to a telescopic wrought-iron pipe. This was capped by a screw-down brass plate, flush with the sidewalk; but the plates were liable to be stolen, and it was found that a further improvement in the method of capping could be made.

The present form of service-box, embodying some old features, includes some 4 ft. of 1¼ or

1½-in. tarred wrought-iron pipe, telescoping into 2 ft. of vitrified pipe, resting on a vitrified clay block. The upper end of the iron pipe is slit for a short distance along four radial lines, and the strips thus formed are turned over. This forms a support for a base plate, with an opening of such shape that a slight turn will lock the plate with the bent pipe strips. Upon the plate rests a thimble, and on the thimble rests the sidewalk plate. The stop-cock is turned by a ⅝-in. rod. The sidewalk case weighs 23 lbs. and costs 69 cts. The remainder of the device costs $1.21, making a total cost of $1.90 per service box. A single top and main service pipe answers for each building, and where there is more than one tenant the branches are generally made and the service boxes set in the sidewalk.

COVERING THE NATICK RESERVOIR WITH A CONCRETE ROOF.

Mr. Frank L. Fuller, of Boston, described in detail the engineering work involved in building elliptical groined arch vaulting over an old reservoir at Natick, Mass. The reservoir receives surface water, and since its construction in 1874 has given more or less trouble through vegetable growths. The roof was added in 1902.

The reservoir is 212 × 217 ft. in plan at the top of the embankments, and about 155 × 160 ft. at the bottom. The total depth is now 19 ft., and the water depth is 17½ ft. After deducting the space occupied by the piers there remains a storage capacity of 4,280,000 gallons. The roof arches have a span of 13½ ft., a rise of 2¾ ft. and a thickness of 6 ins. at the crown. Over the piers the concrete is 3¼ ft. thick, thus making a flat surface for the top of the roof. The upper 12 ft. of the supporting piers is 20 ins. square, in plan, below which the size increases to 24 ins., and then to 27 ins. Alternative bids showed that brick piers would cost $14 each, but that concrete piers could be had for $9.50. Concrete piers were therefore adopted. Mr. F. A. Snow, of Providence, R. I., made the bids named, and secured the contract for the reservoir.

One row of piers was built into the lower part of the inner embankment, but the roof abuts on the upper part of the embankment, which is paved with granite. The roof is covered with 2 ft. of earth.

The concrete for both the roof and the piers was composed of 1 measured part of cement (mostly Atlas), 2½ parts sand and 4½ parts screened gravel. The concrete was mixed by hand, rather wet, and was moved to place in wheelbarrows. The whole cost of the work was $28,870.

In discussing the paper, Mr. Leonard Metcalf, of Boston, reviewed some of the attempts to decrease the cost of groined arch reservoir and filter coverings since the first one in this country was built at Ashland, Wis., by Mr. Wm. Wheeler, in 1895. One of the chief economies has been achieved by lessening the thickness of the concrete over the piers, thus saving from 10 to 30% of the roof material. This and other features of the several roof coverings of this type thus far built in the United States were presented by Mr. Metcalf in a table which is reproduced herewith.

Mr. Wm. B. Fuller, of Paterson, N. J., said that the strength of concrete groined arches can be determined only by actual tests, but heavy loads have been withstood in a number of instances. Local conditions may render impracticable depressions in the concrete over the piers.

THE USE AND WASTE OF WATER BY PUBLIC SCHOOLS AT SYRACUSE, N. Y.

A paper on this subject was sent by Mr. Venner, of Syracuse, and read by Mr. Wm. R. Hill. The water consumption of Syracuse is approaching the capacity of the new gravity pipe line and studies have been instituted to see how the waste may be curtailed. In February, 1903, meters were installed on the 34 public school buildings in the city. Readings for the third month, after opportunity to reduce waste had been afforded, showed an average daily consumption for each pupil ranging from 2.3 to 497 gallons. Of the 34 buildings, 14 showed a consumption of less than 10 gallons a day and 15 of more than 20 gallons a day, while three ran over 100 gallons. For the three months of February, March and April the average was 20 gallons a pupil. All the schools used 450,000 gallons a day, or 3.6% of the total consumption in the city. At current rates this water would cost $1,000 a month, but there are no charges for water supplied to city departments.

TESTS OF 6-IN. WATER METERS AT KNOXVILLE, TENN.

A valuable paper describing loss of pressure and accuracy tests of 6-in. water meters was sent to the convention by Mr. Frank C. Kimball, superintendent of the works owned by the Knoxville Water Co. The tests were initiated by Mr. Elbert Wheeler, of Boston, treasurer of the company named, and a member of the association's committee on charges for private fire protection.

The nine water companies were invited to submit for test a 6-in. meter of each type made by them. One company replied that it made no meter larger than 2 ins.; two companies declined; one promised, but failed to send a meter. The five companies that complied with the test sent nine meters, including four rotary, two disc and two current meters, as follows: Rotary—Hersey, Crown, Empire, Union; disc—Hersey and Keystone; current—Torrent, Gem and Standard.

The tests were made at the river pumping station of the company. Water was taken from a 14-in. reserve force main, through a specially laid 6-in. pipe, 100 ft. in length between the main and a piegometer. The average available static head was 192 ft., or about 83 lbs. when no water was being used.

The general method of making the tests was similar to that described by Mr. John R. Freeman in the "Hydraulics of Fire Streams" and in "The Nozzle as an Assurate Water Meter" (Vols. XXI. and XXIV., Trans, Am. Soc. C .E.) The nozzles employed were a 4-in. and a 2½-in., loaned by the Mutual Fire Insurance Co., of Boston, and a 2-in., 1½-in., 1-in. ,and ½-in., made for the test. For the accuracy tests with small streams the discharges were through fire pipe into a tank on a pair of scales. All the water used in the tests had been previously filtered.

The results of the various tests were presented in the form of several extended tables and one diagram. For as high as 1,200 gallons of water per minute, through a 6-in. meter, the loss of pressure due to the meter ranged from 68.9 to 3.9 lbs. for the various makes. Three meters of the class showing the least loss of pressure were tested with up to 2,500 gallons per minute, and showed losses of 24.9, 23.4, and 16.8 lbs., respectively.

In the accuracy tests with large or full flows through ½ to 4-in. nozzles no water failed to register under 97.3% of the volume as indicated by the nozzles. A few registrations ran to from 101 to 102%, and one was 104.5%.

The extreme sensitiveness tests, in which all the

DATA RELATING TO RESERVOIRS IN THE UNITED STATES COVERED WITH GROINED ARCHES.

(Compiled by Leonard Metcalf, Sept. 1, 1903.)

Date built.	Location and Engineer.	Description.	Depth of Earth Cover. Ft. Ins.	Concrete Mixed.	Arch. Span. Ft. Ins.	Arch. Rise. Ft. Ins.	Arch. Crown thickness. Inches.	Depression over pier. Ins.	Pier section at springing, ft. and ins. and area sq. ft.	Volume saved by depression cu. yds. and equiv. depth in inches.	Mean thickness of roof, inches.	Cost per sq. ft. Dollars.	Pier load tons per sq. ft. above roof springing.
1895	Ashland, Wis. William Wheeler.	Filters, 3 Total net area ¼ acre. Intrados elliptical. Extrados plane. 2 layers (flat) brick backed with concrete.	2—0	1:2½:5 Brick, mortar 1:3	15—9	3—6	6	None	2.33x1.9 = 4.42 2.375x 2 = 4.73 Brick.	None	0.97 = 11.7		12.5
1896	Somersworth, N. H. William Wheeler.	Filters, 2. Total net area ¼ acre. Intrados elliptical. Extrados plane. 1 layer brick on edge backed with concrete	2—6	1:2½:5	16—0	4—0	6	None	2.88x2.83=8.15 Granite.	None	1.088 = 13.0	0.47	9.7
1897	Wellesley, Mass. Freeman C. Coffin.	Reservoir. 80 ft. int. diam. Intrados elliptical. Extrados plane.	2—0	1:2½:5	12—0	2—6	6	None	24x24 = 4 Brick.	None	0.86 = 10.3	0.225	8.9
1899	Concord, Mass. Leonard Metcalf.	Sewage reservoir. 57 ft. int. diam. Intrados elliptical. Extrados plane.	2—6	1:2:5	12—9	3—0	6	None	24x24 = 4 Brick.	None	0.92 = 11.0	0.38	11.7
1899	Albany, N. Y. Allen Hazen.	Filters, 8 beds of 0.7 acre each. Intrados elliptical. Extrados parabolic.	2—0	1:3:5	11—11	2—6	6	6	21x21 = 3.06 Brick.	0.57 1 in.	0.78 = 9.3	0.182 or 0.277 in. filling etc and manholes.	11.0
1899	Clinton, Mass. Frederic P. Stearns. (Metropolitan Water Board.)	Sewage reservoir. 100 ft. int. diam. Intrados Elliptical. Extrados plane.	4—6	1:2½:4	12—0¾	2—6	12	None	30x30 = 6.25 (Under cap or corbel 25x25) Brick.	None	1.40 = 16.8		12.2 at springing. 17.7 at min. section of pier.
1900	Superior, Wis. Allen Hazen.	Filters, 3. Total net area ⅛ acre.	1—8		12—0	2—6	6	6	20x20 = 2.77 Brick.	0.57 = 1 in.	0.77 = 9.2	0.29	10.8
1901	Philadelphia, Pa. Lower Roxborough. John W. Hill.	Filters, 5. Each 0 537 acre area.	2—0	1:3:5	14—0	3—0	6	21	22x22 = 3.36	2.70 cy = 3.5 ins.	0.61 = 7.3		13.3
1902	Milford, Mass. Leonard Metcalf.	Filters, 2. Each ¼ acre area. Intrados elliptical. Extrados parabolic.	1—6	1:2½:5 to 1:3:5	14—0	3—0	6	18	24x24 = 4	2.87 = 8 ins.	0.658 = 7.9	Cost to contractor estimated at 0.36	9.8 16.8 with 4 ft. sand stored on roof.
1902	Philadelphia, Pa. Upper Roxborough. John W. Hill.	Filters, 8 of 0.7 acre area.	2—0	1:3:5	14—0	3—0	6	21	22x22 = 3.36	2.70 = 3.5 ins.	0.61 = 7.3		13.3
1902	Natick, Mass. T. L. Fuller.	Reservoir. Intrados elliptical. Extrados plane.	2—0	1:2½:4½	13—6	2—9	6	None	20x20 = 2.77	None	0.866 = 10.4	0.40 (Concrete at $12.50)	15.1
1903	Ithaca, N. Y. Allen Hazen.	Reservoir. Intrados elliptical. Extrados plane.	2—0	1:2½:4½ = 1 bbl: 9cf :17 cf	10—6	1—6	6		18x18 = 2.25 Pier 17x17				10.9 and 12.2

meters were tried, showed an unrecorded flow, with a ½-in. opening, of from 1.3 to 10.7%, with one as high as 36.5%, and one 2% of over-registrations. Three of the most sensitive meters, with a ¼-in. opening, showed an unrecorded flow of 50.0 to 57.7%.

Tests of meters which had purposely been completely blocked show high percentage deliveries.

The tests described by Mr. Kimball extended over a period of 18 days, during which time various representatives of the meter manufacturers, insurance companies and others were present.

The discussion was opened by Mr. F. H. Crandall, of Burlington, Vt., who said he was present during a large part of the tests. He thought the

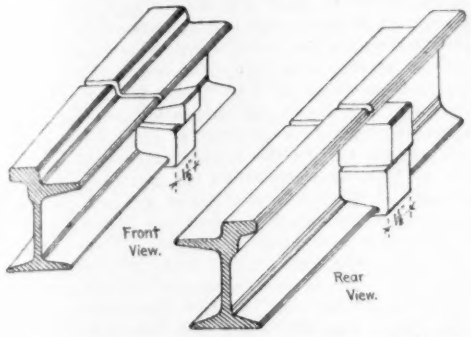


Fig. 1. Early Form of Electric Welding on Girder Rails.

tests plainly showed that large meters are not disastrous at times of fire. Meters that are most accurate in measuring the flow also give rise to the greatest loss of head.

Mr. J. A. Tilden, mechanical engineer and superintendent of the Hersey Manufacturing Co., said that the tests were notable, among other things, because all the water and pressure desired was available; more of each than any of the meter-making companies have at their factories. The meter companies should welcome such comparative tests. The municipal water department at Burlington, Mr. Tilden said, is now preparing to make tests equally as elaborate as those at Knoxville, and with available quantities up to 3,000 gallons or more per minute.

CHARGES FOR PRIVATE FIRE PROTECTION

The committee appointed a year ago to continue a study of this subject submitted a brief report, which was accepted and adopted. The committee stated that it seems only just that water supplied for private fire protection (as for mills and factories) ought to be measured and paid for. The maximum allowable private service of 6 ins was suggested, and it was stated that in no case should a private service be allowed to draw more than 33% of the total amount of water passing through the main with which it is connected.

ELECTRIC PUMPING PLANTS OF THE MONTREAL WATER & POWER CO.

Mr. F. H. Pitcher, engineer of the company named just above, read a paper which described in detail the electric power pumps at three different stations of the company. These stations supply water at three different levels to a small portion of Montreal, and to a number of outlying municipalities. The water is drawn from the St. Lawrence River.

At the low-level station there is a 5,400,000 (Imp.) gallon electric triplex pump, put in operation in 1899, and a 2,500,000 (Imp.) gallon pump added since then. There are two small steam pumps in reserve at the same station. At the middle level station there is a 4,500,000 (Imp.) gallon electric pump, working under a pressure of 118 lbs. By changing a pinion this pump can be worked at a rate of 7,000,000 (Imp.) gallons, and ultimately it will be operated under 175 lbs. pressure. The larger pump at the lower station is driven by a 480-HP. two-phase motor, and the pump at the middle station is driven by a 400-HP three-phase motor. There is a fourth electric pump of small size, at the upper or mountain station.

Large electric pumps require less attendance and less capital outlay than steam pumps of the same capacity. In residence sections they have the advantage, over steam power, of causing no smoke, but the disadvantage of vibration and noise. Another disadvantage of electric pumps is that usually the power is not under the control of the owner of the water-works. The power at Montreal is all hydro-electric, as is nearly all the electric power now used in the city.

THE FILTER PLANT AT LAWRENCE, MASS.

This well-known plant was described, with the aid of lantern slides, by Mr. M. F. Collins, superintendent of water-works at Lawrence. Division walls have been built to separate the old single bed of 2½ acres area into three beds, so that only one-third of the area need be thrown out of service for cleaning. The walls are of concrete. Plans for a new covered filter, similar in design to those at Albany and Philadelphia, have been made by Mr. Morris Knowles, now of Pittsburg. There would be one bed, with a net area of about ¾ acre. The space to be occupied by the new bed would be largely regained from the river by piles and timber work and filling.

OTHER PAPERS.

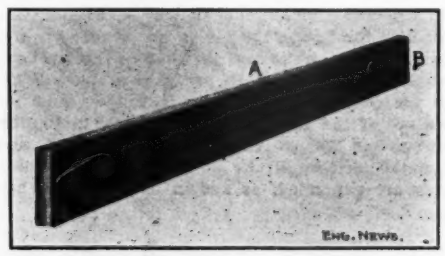
Mr. John A. Hall, of Quincy, Mass., read a paper on the "Reciprocal Obligations of the Management of a Water Supply and the Community." He favored the distribution of the whole cost of service according to benefits conferred, and advocated the use of meters.

Mr. Leonard Metcalf, of Boston, gave a lantern-slide talk, entitled "Glimpses of Porto Rico." Mr. Frederick Brooks, also of Boston, set forth "The Folly of Reckoning by Gallons Which Differ Widely in Canada and the United States, While Both Countries Have Identical Liters and Cubic Meters." Several papers on the program were postponed to some of the coming monthly meetings, when it is hoped that their authors, who were not at this convention, would be present.

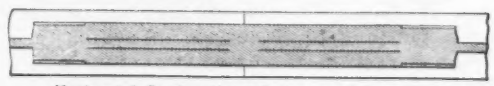
ELECTRIC WELDED JOINTS FOR STREET RAILWAY TRACK.*

By William Pestell.†

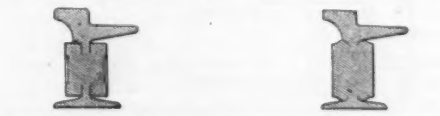
In 1892 the Johnson Company, of Johnstown, Pa., organized a department for electric welding of track, working under the patents of Prof. Elihu Thomson, of Lynn, Mass. In 1893 and 1894 the Johnson Company welded about fifty (50) miles of track in the cities of Boston, Cleveland, Brooklyn, Johnstown, Detroit and St. Louis. The track welded had been laid for some time and was in



View of Bar for Welding.



Horizontal Section through Bars and Rail Web.



Section Through End Weld. Section Through Center Weld.

Fig. 3. Present Form of Electric Welded Joint.

bad condition so that the first work attempted was repair work rather than construction.

The first welds were made by welding a short vertical bar directly over the joint, as shown by the sketch, Fig. 1. This weld was made under pressure, but the pressure was not continued after the weld was completed and the metal became porous in cooling, leaving a mechanically weak joint. A great deal of tendency to porosity in the metal was undoubtedly due to the burning of the rail and the bars at the small points of contact then used.

*Abstract of a paper presented before the American Street Railway Association at Saratoga Springs, N. Y., September, 1903.

†Worcester Consolidated St. Ry. Co., Worcester, Mass.

To overcome the tendency of burning and porosity in the metal, a form of weld, Fig. 2, was devised, two distinct welds being made at each joint, practically butt welding the rail ends together. As in the previous case, the welding was done under pressure, but the pressure was immediately released when the weld was completed; the result again was that the weld was porous and weak mechanically, and in addition the heat being applied directly at the head of the rail the latter bulged so that it became necessary to plane it down to a working surface after welding.

A great number of breaks occurred in both the above types of weld and in each case the track opened up from ¼-in. to ½-in. The breaks occurred soon after welding, usually during the first 24 hours. The welding company was led to believe from the nature of the breaks and from

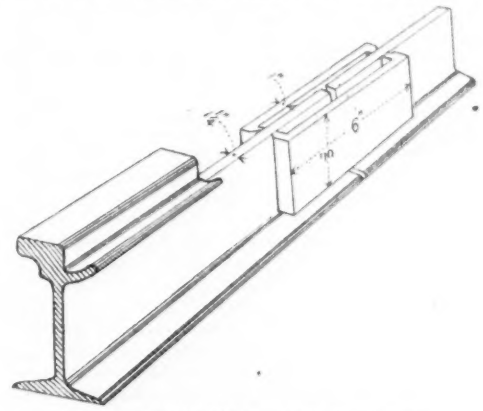


Fig. 2. Electric Welding with Short Bars.

the opening in the track after breaks occurred that the same were due to strains in the rail from contraction after welding. They then devised a machine to compress a length of track before and during the welding, the idea being to put enough compression into the track while welding to prevent any tendency to contraction strains after welding. While this reduced the breaks to some extent, breakage was still excessive and the porosity of the metal at the fracture led the welding company to believe that a change had taken place in the metal from the passage of the electric current through it, and commercial welding was discontinued until some method of overcoming the defects could be devised in the company's shops. Experiments were carried on continually both from a chemical and mechanical standpoint from 1895 to 1897, and it was proven conclusively that heating the metal by electricity had no more injurious effect on it than heating by any other source. At the latter part of the experiments it was discovered that by making the weld under pressure and increasing the pressure as the weld was completed, continuing the pressure until the weld had practically cooled, the metal was left in a dense condition, free from porosity and of high tensile strength. It was also found that any part of the weld that had not been subject to the above condition was of a porous nature and weak mechanically. This led to the making of projections or bosses on the bars which were as at B, Fig. 3, the bars being placed one on each side of the rail and welded in their places directly to the web of rail, the center weld being made through a loose piece of metal dropped on the bar (A, Fig. 3) rather than by a boss on the bar.

The welding plant consisted of five cars—the sand car, welding car, rotary converter car, booster and motor car and motor and emery wheel car for finishing. The cars are run on the track by their own motors and can be sent from place to place over the different roads wherever there are connecting lines. Recent improvements have reduced the number of cars from five to four and instead of regulating on the direct-current side of the rotary transformer by a motor generator, the regulating is done on the alternating-current side by means of variations in the connections of a regulating transformer. This type of machine has reduced the amount of current taken from the trolley from a maximum of 500 amperes to a maximum of 300 amperes under adverse conditions. At the present time all welds are made by means of two steel bars, usually 1 × 3½ ins. in section and from 18 ins. to 48 ins. long, 18 ins. being the shortest bar used even where the holes are not drilled in the rail, the greater lengths depending on the distance of drilled or punched holes from the end of rail. It is not safe to weld on bars where holes are nearer than 3 ins. from end of the bar. The same size bar is used on both 6-in. and 9-in. rail, the strength of the bar being ample to support the joint directly at the weld without the bar mechanically fitting the rail.

The first mile of track welded under the system using long plates was welded in the fall of 1897 on the Johnstown Passenger Railway Co., Johnstown, Pa. The rail was 6-in. girder, 78 lbs. to the yard.

Breaks to date have been three; the street is macadamized, no paving. Next welding, Nassau Elec. Ry. Co., Brooklyn, N. Y., Fifth Ave. from Atlantic Ave. to 39th St., Marcy Ave. from Fulton St. to Flatbush Ave., and So. 1f

St., a total of 9 miles. This Brooklyn rail was 9-in. girder laid in paved streets; at the end of the first year there had been 8 breaks.

From the experience of Buffalo and Rochester, New York, and Columbus, O., where new track has been welded, it would appear that in cities where permanent grades had been established and the liability of changes in track location are apparently remote, the electric welding of new tracks seems advisable. The expense of original construction should certainly be much less than it would be several years later when the joints commence to go down, and it is a question whether it would not be cheaper than a good splice bar joint bonded to the same capacity. From tests made by the General Electric Co. and the writer on electrically welded joints, the conductivity equals from 130 to 140% on 6-in. girder rail and from 110 to 120% on 9-in. girder, compared with equal lengths of solid rail. Appended is a table showing the mileage of welded track in service:

Table Showing Mileage of Electrically Welded Track in this Country To-Day.

Place.	Year.	Miles.
Johnstown, Pa.	1897	1.
Brooklyn, N. Y.	1898	9.
Buffalo, N. Y.	1899	39.
Buffalo, N. Y.	1900	60.5
Lockport, N. Y.	1900	1.
Buffalo, N. Y.	1901	6.
Rochester, N. Y.	1901	18.
Rochester, N. Y.	1902	8.5
Columbus, O.	1902	18.
Worcester, Mass.	1902	22.
Lawrence, Mass.	1902	4.2
Lowell, Mass.	1902	6.8
Lowell, Mass.	1903	14.
Total miles welded		208.

As to the number of breakages likely to occur, the following table, showing the joint breakages within one year after welding on the lines of the International Ry. Co., of Buffalo, N. Y., may be of value:

	Joints welded.	No.	First Year. Joints welded.		No.	Joints welded.		No.
Rail.	1899.	broken.	1900.	1899-1900.	broken.	1901.	'99-'00-'01.	broken.
Old, 6-in.	4,787	18	11,973	16,760	127	482	17,242	8
Old, 7-in.	8	....	566	574	7	....	574	1
Old, J. Co., 9-in.	2,658	49	1,894	4,552	25	356	4,908	7
Old, P. S. Co., 9-in.	74	3	146	220	6	....	220	1
New, 6-in.	....	....	619	619	2	....	619	...
New, 9-in.	3,822	45	2,234	6,056	16	597	6,653	3
Totals	11,349	115	17,432	28,781	183	1,435	30,216	20

PROGRESS ON THE SIMPLON TUNNEL during the three months ending June 30, 1903, is reported as follows: North end, bottom heading advanced 496 m., top heading advanced 434 m., tunnel No. 2 advanced 510 m.; south end, bottom heading advanced 436 m., top heading 810 m., tunnel No. 2 advanced 438 m. The excavation to full section advanced 496 m. in the north end, and 665 m. in the south end. The total amount of excavation during the three months was 23 995 cu. m. in the north end, and 27,130 cu. m. in the south end, while respectively 6,138 and 8,056 cu. m. masonry lining were placed in the two ends. Machine drilling (hydraulic drills, in headings only) and the corresponding mucking consumed 7,976 working hours and 47,735 kg. dynamite, and yielded 11,287 cu. m. excavation; while hand drilling consumed 115,495 working days and 25,064 kg. dynamite, and produced 38,074 cu. m. excavation. The average number of employees was 3,418, of whom 2,466 worked in the tunnel. The rock passed through by the north heading was in general a fine-grained gneiss changing to micaschist, and later to schistose dolomitic limestone. The advance of the south heading lay wholly in schistose gneiss with occasional masses of coarse Antigorio gneiss. The rock temperature at the face was 50 to 52.5° C. (about 125° F.) in the north heading, and about 40° C. (104° F.) in the south heading. The completed quantities at the end of June, 1903, are shown in the following table:

	North End.	South End.	Total
Bottom heading, m.	9,427	6,766	16,193
Top heading	8,617	6,192	14,809
Tunnel No. 2.	9,315	6,730	16,045
Full section	8,611	6,011	14,622
Length of lining.	8,414	5,824	14,238
Total excavating, cu. m.	407,306	295,024	702,390
Masonry, cu. m.	85,712	65,156	150,868

NOTES FROM THE ENGINEERING SCHOOLS.

THAYER SCHOOL.—A meeting of the alumni of the Thayer School of Civil Engineering residing in and near New York was held at the Murray Hill Hotel on the evening of Sept. 11. Over a score of alumni were present, including two from Philadelphia,. After an enjoyable social reunion at the dinner table, adjournment was made to a parlor, where the meeting was addressed by the Director, Prof. Robt. Fletcher, and by President William J. Tucker. The work of the Thayer School in the past was reviewed, its present outlook, needs and interests discussed, and an association of graduates and former students organized, with Mr. A. B. Clark, of 100 Broadway, President; Mr. Wm. C. Phelps, Assistant Engineer Rapid Transit Construction Co., Secretary; and Mr. Edw. J. Morrison, Chief Engineer and Supt. of the Hastings Pavement Co., third member of the executive committee.

GAS ENGINE PRINCIPLES AND MANAGEMENT.

By E. W. Roberts.*

An understanding of the principles of operation, while not positively essential to the management of a gas engine, is nevertheless of great help. This is especially true in case of trouble and assists in quickly locating the seat of the derangement. For this reason, I will first briefly describe the principles of the two types in general use and also the principles of accessory devices for using liquid fuels.

GENERAL PRINCIPLES OF OPERATION.

The type in most common use is the Beau-de-Rochas cycle, otherwise known as the "Otto" cycle. It is now most frequently spoken of as the four-cycle engine, an abbreviation of four-stroke cycle, as it requires four strokes of the piston to complete the cycle of operations necessary for the consumption of one charge of fuel. The other type, largely in use for motor boats, is the two-cycle, an abbreviation of two-stroke cycle, since it requires two strokes of the piston to complete the cycle or series of operations.

The principles of operation of the four-cycle type are illustrated in Figs. 1 to 4. Nearly all gas engines have trunk pistons taking impulses at one end of the cylinder only. During the first stroke of the cycle the piston moves toward the crank-shaft, drawing a charge of fuel and air into the cylinder through the inlet valve, I. Just as the piston reaches the end of its outward stroke, or immediately thereafter, the valve, I, is closed and the content of the cylinder is compressed by the returning piston, as shown in Fig. 2. As shown in the figure, the piston has reached nearly the end of its stroke and just before the stroke is completed, the igniter, G, produces a spark igniting the mixture. An explosion follows and the pressure of the gases rises to from 200 to 400 lbs. per sq. in. The valves still remain closed, and upon the next outstroke of the piston the burnt gases are expanded, as shown in Fig. 3. When about 90% of the expansion stroke is completed the exhaust valve, E, begins to open and the products of combustion to escape to the atmosphere. On the return stroke of the piston, these gases are expelled from the cylinder, the exhaust valve remaining open until the end of the stroke, as shown in Fig. 4. So soon as the exhaust stroke is completed the exhaust valve closes, the inlet valve opens and the cycle is repeated. The complete series of operations comprising the cycle may be summarized briefly as follows:

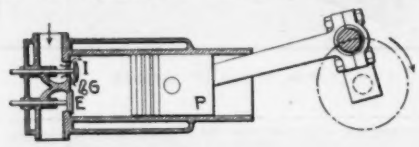


Fig. 1. Suction Stroke.

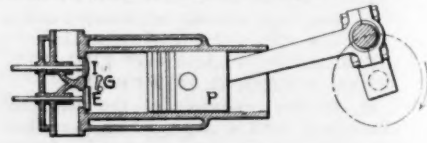


Fig. 3. Expansion Stroke.

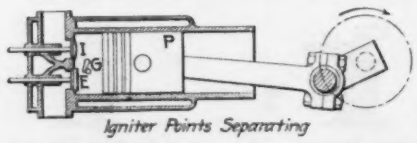


Fig. 2. Compression Stroke.

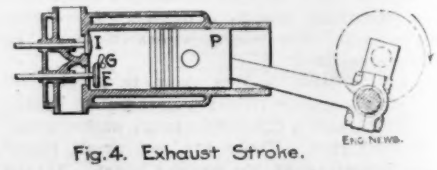


Fig. 4. Exhaust Stroke.

FIGS. 1 TO 4. DIAGRAMS ILLUSTRATING OPERATION OF FOUR-STROKE CYCLE GAS ENGINE.

(1) First stroke; suction stroke; inlet valve open; cylinder charged.

(2) Second stroke; compression stroke; both valves closed; charge compressed, and ignited just before the stroke is finished.

(3) Third stroke; expansion stroke; charge expanded.

(4) Fourth stroke; exhaust stroke; cylinder cleared of burnt gases.

In the two-cycle engine the exhaust and the suction strokes are eliminated by enclosing the crank in an air-tight case and using the crank-case as a pump. The mixture is drawn into the crank-case, slightly compressed, and then forced into the cylinder above the piston.

The series of operations in a two-cycle engine is illustrated in Figs. 5 and 6. Taking first the operations in the crank-case, the mixture is drawn into it through the check valve, S, just as in the suction stroke of a four-cycle engine, while the piston is on its up stroke. On the following down stroke of the piston the charge is compressed in the crank-case to a pressure of from 4 lbs. to 6 lbs. per sq. in. In the cylinder above the piston the cycle is as follows: As the piston nears the bottom of its stroke the burnt gases from the previous cycle escape through the exhaust port, E, which is uncovered by the piston just before it reaches the end of its stroke. Immediately after the exhaust port is opened the piston uncovers the inlet port, I, and communication is established with the crank-case by means of the by-pass, B. The slightly compressed mixture flows from the crank-case into the upper portion of the cylinder and is prevented from rushing across and out of the exhaust port by the deflecting plate, D. The ports are so proportioned that none of the fresh mixture escapes. The up stroke of the piston compresses the charge, and ignition, explosion and expansion follow, as in the four-cycle engine.

A type of two-cycle engine in which the check valve is eliminated is illustrated in Fig. 7. In this form the air is admitted to the crank-case through a port, O, in the side which is uncovered by the piston in the same manner as the inlet and the exhaust ports. This form is especially adapted to high speeds and has proven very successful in automobile practice.

The series of operations comprising the two-stroke cycle may be summarized as follows:

(1) First stroke; compression in the cylinder with ignition; suction in the crank-case.

(2) Second stroke; expansion and exhaust in the cylinder; compression in the crank-case.

There is still another type of the two-cycle engine which has been developed in Germany for large power units. In this type, instead of using an enclosed crank chamber for an air pump, a separate pump cylinder is employed and the air pressure carried to 22 lbs. per sq. in. The latest form of large two-cycle (the Koerting) is double-acting, the piston and the piston rod being hollow and water-cooled. The exhaust port is uncovered by the piston, as in Figs. 5 to 7, but an inlet valve similar to that employed on a four-cycle engine is employed. A mid-section of a Koerting engine cylinder is shown in Fig. 8. It will be noted that the piston, P, is very long and the exhaust port is situated midway of the cylinder. At either end of the cylinder is a cam-operated inlet valve, V. In delivering the charge from the pump, the first portion is pure air, which scavenges the

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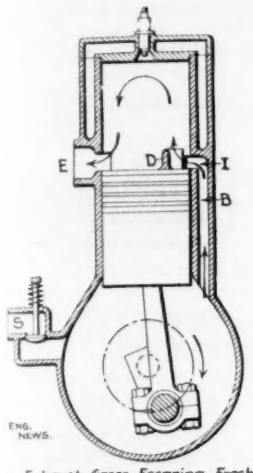
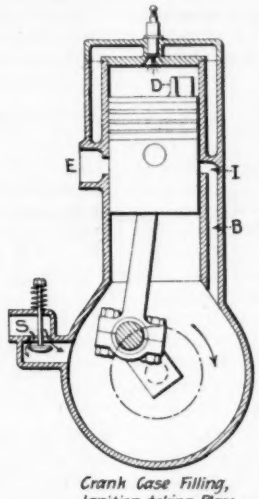
cylinder. The mixture of fuel and air coming after does not escape through the exhaust port, and therefore none of the fuel is wasted. Its fuel economy is said to be high. It will be seen that it receives the same number of impulses in a revolution as a double-acting steam engine.

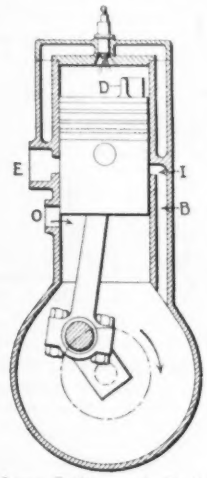
There is still a third type of gas-engine cycle, which has as yet had no general introduction.



Exhaust Gases Escaping, Fresh Mixture Entering from Crank Case.
Fig. 5.



Crank Case Filling, Ignition taking Place.
Fig. 6.



Same Position as in Fig. 6, but Crank Case Opened by Piston.
Fig. 7.

FIGS. 5. TO 7. DIAGRAMS ILLUSTRATING OPERATION OF TWO-STROKE CYCLE GAS ENGINE.

This is the Diesel cycle, invented by a German scientist in 1897. This is a four-stroke cycle, but instead of compressing a mixture of fuel and air, air only is drawn into the cylinder during the suction stroke. The air is then compressed to 550 lbs. per sq. in., which raises its temperature to the combustion temperature of the fuel. Just as the piston passes the dead center at the end of the compression stroke, the fuel is introduced at a pressure somewhat in excess of the pressure of compression and burns as it enters. As the piston proceeds on the expansion stroke, the temperature of the cylinder content is retained at that of compression by the heat of the burning fuel until the latter is cut off. The temperature then falls and the remaining portion of the expansion line is similar to that in the ordinary four-cycle engine. The fuel can be given a variable cut-off and the amount admitted be made proportional to the load. This, it will be seen, is analogous to the variable cut-off in a steam engine. The high range of temperature obtained in this engine gives it a thermodynamic efficiency greater than that realized in any other type of heat motor. The engine has been operated quite successfully on crude oil. It appears that the mechanical difficulties involved have so far delayed its more general introduction. If the latest reports are to be believed it is now being installed for power purposes.

IGNITION.

The most important and the most delicate part of the gas engine is the igniter. As the power impulse depends upon the ignition of the charge, failure of the igniter will cause the engine to miss

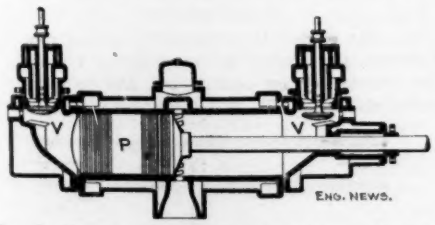


Fig. 8. Diagram Section of Cylinder of Koerting Gas Engine.

explosions, and if misfires continue it will slow down and finally stop. Probably 75% of gas-engine troubles are igniter troubles. Gas-engine igniters may be divided into three classes, i. e., naked flame, a heated metal surface and an electric spark.

The first method is best illustrated by Barnett's ignition cock, Fig. 9. It will be seen to consist of a double jet. The jet, f, is contained in the plug, A, which is rotated by the mechanism of the engine and the opening alternately presented to the flame, F, and the interior of the cylinder through the ignition port shown by the dotted lines. The explosion blows out the flame, f, hence it must be ignited each time by the flame, F.

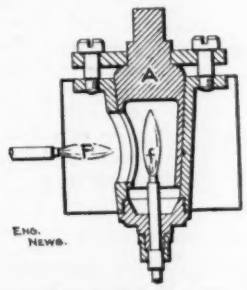


Fig. 9. Barnett's Ignition Cock for Naked Flame Ignition.

Flame ignition is practically obsolete. There are, however, a few Otto slide-valve engines still in use, and in these engines a hole in the slide performs the function of the ignition cock in Fig. 9.

Tube ignition is the best example of the prevailing practice of the second method. In its simplest form, as shown in Fig. 10, a tube of some refractory substance is placed with its open end in communication with the cylinder, C. The tube, T, is heated to a red heat by the Bunsen burner, B, which is supplied with the same fuel as is used to operate the engine. When the engine exhausts, a portion of the products of combustion remain in the tube, blanketing the heated portion until the compressed fresh charge forces the dead gas back into the tube past the "hot spot." By moving the burner toward the closed end of the tube or by shortening it, the time of ignition may be retarded. The opposite course makes the ignition take place earlier. Ignition tubes are made of wrought-iron gas pipe welded together at the end, of porcelain, of platinum and of a special nickel alloy. Wrought-iron tubes rarely last more than a few days. Platinum well taken care of will last several months, as will porcelain if kept from drafts which tend to cool it suddenly. Nickel-alloy tubes are the cheapest for the service rendered, as they will last from a year to 18 months.

Another form of ignition by means of a heated surface consists of a chamber divided from the cylinder into which the fuel, usually kerosene, is pumped. The contents of the chamber are too rich in fuel for ignition and when sufficient air is forced in from the cylinder to form an explosive mixture the charge takes fire. There are still other forms not very much used and hence not worth while explaining here.

As a general thing, and especially in engines for portable purposes, electrical ignition methods are supplanting the older forms. There are two principal types of electric igniters in use, and a third is now in a fair way of being introduced. In the first, known as primary ignition, the current from a battery or a generator is made to pass through a coil having a certain amount of self-induction and the breaking of this circuit inside of the cylinder produces the igniting spark. The second type employs the Ruhmkorff coil, in which the low-tension current is transformed into one of high pressure that will jump across a gap in the cylinder when the primary circuit is broken. On account of the spark jumping a gap, this type is known as the "jump-spark" system. The third method consists of passing the current from the battery through a wire of high resistance inside the cylinder. The wire is heated sufficiently to produce ignition much in the same manner as with the hot tube. This is known as the catalytic system, on account of ignition being produced by contact. As yet, it is but little used.

The primary system of ignition makes use of the property of an electromagnet to produce a current in a surrounding wire when the strength of the magnet is altered. The pressure or voltage of the induced current is in proportion to the magnitude of the change of the magnet's strength and the rapidity with which the change is made. The spark coil used for primary ignition is an electromagnet consisting of a bundle of soft-iron wire surrounded with a coil of insulated copper wire. When the current from the battery flows through the coil the iron core is magnetized. If the current be broken, it will be seen that the strength of the magnet will immediately fall to zero. The rapid change in the strength of the magnet produces an induced current in the coil of much higher pressure than that from the battery and this current jumps the short gap produced during the first portion of the break, giving a bright spark.

A diagram of the primary ignition system is shown in Fig. 11. In the figure the coil is shown at C, in section. At c will be seen the bundle of small iron wires forming the core. Around these is wound the coil of insulated wire, w, the ends of which are connected to the binding posts, b b. One binding post is electrically connected to one terminal of the battery, B, while the other terminal of the battery is connected to the frame or other part of the engine. The other binding post of the coil is connected to the insulated electrode of the igniter, I. Fastening one wire of the circuit to the engine is known as "grounding" it on the engine. The mechanical operation of this igniter is as follows:

The arm of the movable point or electrode, m, is first forced into contact with the insulated electrode, n, and held in the position for a moment. Then the arm is suddenly drawn away, breaking the circuit, and the sudden drop in the magnetism of the core induces a high-pressure current in the circuit. This current has a voltage strong enough to make it bridge the small gap which is made just as the circuit begins to open. It is absolutely necessary that the circuit remains closed long enough to fully magnetize the core. If the time of contact is too short the spark will be weaker and may not be sufficient to ignite the charge. The longer the coil, the longer will be the time required to fully magnetize the core, and it is for this reason that short coils are best for high-speed engines.

The second method of electrical ignition, the jump-spark method, is shown diagrammatically in Fig. 12. The Ruhmkorff or jump-spark coil is like an ordinary spark coil, about which has been wound a second coil of fine wire many times longer than the inner coil. When the circuit is made and broken in the heavy wire coil, there is a small spark produced at the break of the primary or thick-wire circuit, and at the same time the rapid fall in magnetism induces a current in the fine-wire coil. As the pressure of the induced current is in proportion to the number of turns in the coil, it will be seen that the current induced in the fine-wire coil must have a very high pressure. The higher the pressure of an electrical current the higher is the air-gap that it will bridge. These coils are so designed that they will give a spark capable of bridging a gap from 1-32-in. to ⅛-in. and have sufficient current strength to ignite the charge. They are, of course, capable of producing a spark much longer than this, but the short gap produces what is known as a "fat spark" that is sure to ignite the mixture.

In the figure, a is the core of iron wire about

which is wound the primary coil, p. On the outside of this coil is wound the secondary coils. It is found that a rapid series of breaks in the primary circuit is more certain to produce a good spark at the secondary and for this reason many jump-spark coils are provided with a vibrator. This vibrator is shown in the figure and consists of the soft-iron armature, j, attached to a flat spring, i. One side of the circuit leading to the primary coil is attached to this spring and the other to the post carrying the small screw, o. This screw is fitted with a platinum point, f, which is

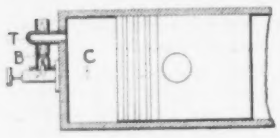


Fig. 10. Diagram Illustrating Method of Tube Ignition.

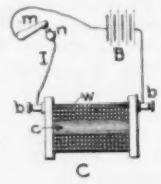


Fig. 11.—Diagram Illustrating Primary System of Electric Ignition.

which it goes through a binding post on the coil to one end of the primary. The other end of the circuit is attached to the binding post connected to the vibrator, whence it passes to the other end of the primary winding. It may be said that the secondary coil is the generator for the spark plug, the connections for which are easily followed. It will be readily seen that one end of the secondary is attached to the central core, e, while the other end is grounded on the engine. In order to decrease the volume of the primary spark at the vibrator, it is customary to connect an electrical condenser

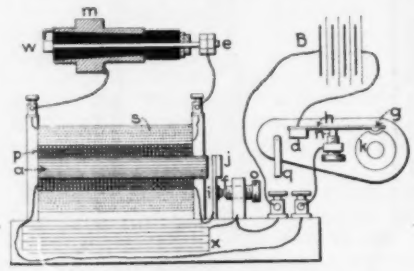


Fig. 12. Diagram Illustrating Jump-Spark System of Electric Ignition.

engine. Many of the later type of vaporizer do not transform the fuel into vapor immediately, but atomize it, distributing it in a finely divided state throughout the charge of air, after which it is vaporized either on the way to the cylinder or in the cylinder itself. The writer includes all atomizing devices, with the exception of the jet operated by a fuel pump, under the general head of vaporizers.

The simplest form of vaporizer is undoubtedly that illustrated in Fig. 14. It consists of nothing more than a branch pipe from the gasoline tank,

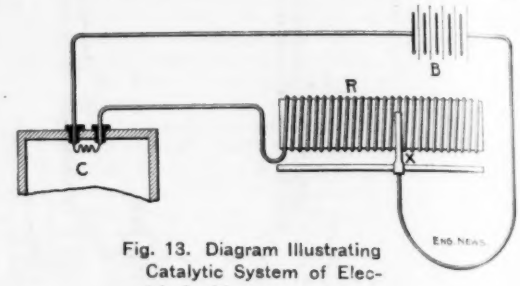


Fig. 13. Diagram Illustrating Catalytic System of Electric Ignition.

normally in contact with a platinum contact piece on the spring, i. When the primary circuit is closed the core is magnetized and attracts the armature j, bending the spring and breaking the circuit at f. Breaking the circuit demagnetizes the core and the spring is released, closing the circuit at the vibrator, when the operation is repeated.

The spark plug is shown at m. It consists of a steel body and an interior core of some insulating material, either porcelain, mica, or lava. Through the center of this core passes a steel rod, e, having a knob at the inner end. A short platinum wire, w, is inserted into the inner end of the body, and bent as shown in the figure, so that it nearly but not quite touches the knob on e. It is at this point that the spark jumps across to ignite the charge.

The spark is controlled by a switch on the engine, one type of which is illustrated at the right of the figure. It consists of a cam, k, having a notch in its periphery. This cam bears against a spring, h, to which is attached a platinum contact at n. A similar piece of platinum is fixed to the end of the adjusting screw. The spring is attached at d to a fiber base which is free to rotate about the shaft carrying the cam and which is held in position by means of the rod, d. Each time the notch in the cam comes opposite the knob on the spring it allows the contacts to meet and the primary circuit is closed. This cam is attached to the lay-shaft of the engine if it be of the four-cycle type and to the crank-shaft if the engine is of the two-cycle type.

The time of ignition may be readily altered by turning the switch about the shaft by means of the rod q. If the cam is rotating in the direction of the arrow and the switch is rotated in the same direction, the time of the ignition is retarded. If the switch is rotated in a direction opposite to the movement of the cam, the time of ignition is advanced. This is known as changing the lead of the spark. If the igniter fires the charge before the piston reaches the end of the compression

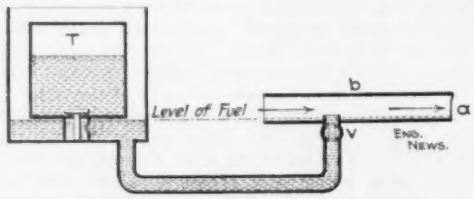


Fig. 14. Tank and Pipe Form of Vaporizer.

stroke, the lead is said to be positive. If the spark occurs after the piston has passed the end of the compression stroke and during the expansion stroke, the lead is negative.

The circuits of this system are as follows: Current passes from the battery, B, to the spring, h, and thence to the switch adjusting screw, from

across the gap, as shown in the figure. The condenser, which is made of alternate layers of tinfoil and oiled paper, absorbs a portion of the surplus pressure at the break and gives it off gradually. This prevents the platinum points from being rapidly burned away.

The third method of electrical ignition is shown in Fig. 13. In this system no electromagnet is necessary. A coil of wire, c, of some refractory metal, is placed in the cylinder and connected to the battery through a variable resistance, R. The coil is kept at a temperature too low to ignite the mixture at the ordinary pressure and temperature. But when the pressure and the temperature of the charge is increased the temperature of the coil rises and the charge takes fire at the proper time in the cycle. The temperature of the coil may be raised or lowered at the will of the operator by cutting out or cutting in resistance with the movable contact, x. By increasing the temperature of the coil the time of ignition is advanced and vice versa. The method is still in the experimental stage and may not come into practical use. It originated in Europe and the writer believes that it has been little used outside of the laboratory.

FUEL MIXING DEVICES.

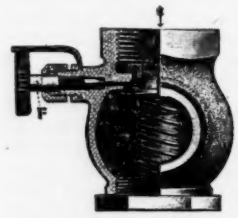
For a gas engine using a stable gas, the mixing device is very simple. It may be either a double-ported valve, or two valves working together. It is among the apparatus for liquid fuels that are found the greatest number of appliances, both simple and complicated. The writer will pass the gas mixers with the above explanation and take up at once the devices for handling gasoline and the heavier fuels. Gasoline mixing devices may be divided into three classes. These are carbureters, vaporizers and jet feeds.

The carbureter, properly so called, is a device for mixing gasoline with air by either infiltration or evaporation, or in other words, by passing air either over or through the body of the liquid. The mixture thus obtained is invariably too rich for power purposes and must be diluted with air before it is taken into the cylinder of the engine. Carbureters may be divided into filtering and surface carbureters. In the filtering carbureter the air is passed to the bottom of a vessel containing the fuel and allowed to bubble up through it. In the surface carbureter, the air passes over the surface of the fuel, the surface being sometimes enlarged by means of wicks projecting from the liquid. Carbureters are now practically obsolete for power purposes, as they leave a residue of fuel in the tank which is too heavy for engine use and also they are very sensitive to changes in the humidity or the temperature of the atmosphere.

The vaporizer, which is often, but the writer believes erroneously, called a carbureter, is a device for transforming into vapor just the quantity of the fuel which is needed for one charge of the

T, to the inlet pipe, b. The end of the gasoline pipe is directly in the path of the ingoing air and slightly above the level of the fuel in the tank. The draft of passing air draws the fuel with it and it mixes with the air on the way to the engine. The mixture is controlled by the valve, v.

Another very simple form of vaporizer is that known as the "James" valve and is illustrated in Fig. 15. It is nothing more than a special check valve in which a passage is made to the valve seat for the fuel. The fuel flows to the valve by gravitation and is drawn with the air as it passes by the valve. The cut requires no further explanation, except that the flow of gasoline is regulated by means of the needle valve, F.



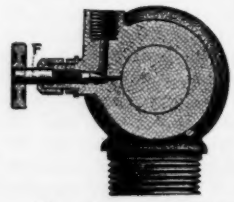


Fig. 15. James Valve Type of Vaporizer.

The greater number of the modern forms of automobile vaporizer are based on the principle of either Fig. 14 or Fig. 15. These figures show the operating principle, the modifications being simply means for controlling the air and the proportions of the mixture.

The principle of the jet feed is shown in Fig. 16. A pump so designed that it will handle minute quantities of the fuel is arranged to supply to the engine just the quantity needed for one charge and no more. The jet, J, is generally arranged so that it opens into the inlet pipe against the side of which the fuel is projected so that it breaks up into a finely divided state. For a certain class of stationary engines this form gives very good service.

GOVERNING.

The gas engine is governed in one of two different ways. Either by varying the strength of the impulse or by cutting out one or more impulses entirely. The first method is known as the

Fig. 16. Jet Feed Vaporizer.

variable impulse system and the latter the hit-or-miss system.

In the variable impulse method the force of the explosion may be reduced by throttling the ingoing charge, by reducing the proportion of fuel, or by retarding the ignition.

The hit-or-miss system covers holding the exhaust valve open so that air is drawn in through

the exhaust port and no charge enters the cylinder; holding the fuel valve shut so that pure air only enters; cutting out the current from the igniter, and alternately expanding and compressing a charge; and stopping the action of the entire valve mechanism, usually with the exhaust valve held open. The only governor mechanism that it will be necessary to illustrate in connection with this article is the pendulum governor, which is peculiar to the gas engine. The gas engine employs, in addition to this style of governor, all varieties that are used with the steam engine. As these are no doubt familiar to the readers of this paper, they will be omitted.

The pendulum governor is illustrated in principle in Fig. 17. In the figure, S represents the stem of the exhaust valve and M the push rod, which is operated by the valve mechanism once for each two revolutions of the crank-shaft. At c is a catch so arranged that it will normally spring away from the block, G, which is fast to S. The pendulum weight, P, is attached by means of a set screw to the light bell crank, one arm of which (a) lies just beneath the catch, c. The pendulum, being pivoted to the pushrod at p, is free to swing. So long as the speed of the push rod does not exceed the rate of swing of the pendulum it will be carried with the rod without swinging. So soon as the speed of the rod exceeds the rate of swing, the weight lags behind and pushes the catch, c, in the way of B, holding the exhaust valve open. The speed of the engine may be adjusted by setting the weight higher to increase the revolutions per minute or lower to decrease the speed.

The centrifugal shaft governor, and the conical pendulum governor are the types usually employed to control the engine on the variable impulse system, and these types of governor are also employed to operate hit-or-miss devices. The greater simplicity of the pendulum governor for hit-or-miss makes it the favorite for this system.

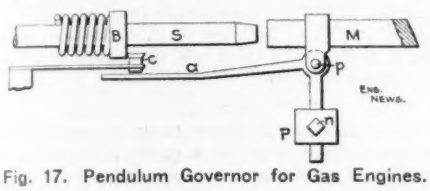


Fig. 17. Pendulum Governor for Gas Engines.

STARTING.

Before starting a gas engine it is the best plan first to fill all the oil cups, even if there is oil in them. Then look over the electric circuit, or light the burner for the tube. See that the tube has acquired a dull red heat before attempting to start the engine. Open the gas valve to about one-half the normal distance and throw the starting lever to the proper position or open the relief cock. In a gasoline engine, either flush the vaporizer or open the needle valve a short distance. Large engines may be started by pouring a small quantity of gasoline into the cylinder with the engine on the expansion stroke and a charge of air drawn in. Then if the flywheel is given a quick turn backward and the igniter snapped, the piston will generally get an impulse strong enough to let the engine take up its cycle. Just so soon as the engine has started attend at once to the water and see that it is flowing freely through the jacket. After the engine has been running for ten or fifteen minutes adjust the flow of water so that the outlet is as hot as can be borne by the hand. This will be found to be about 150° F. This is about the best temperature for a gas engine. For a gasoline engine the water may be as hot as 180° and for an oil engine using kerosene, the water may be allowed to approach the boiling point.

STOPPING.

In stopping, it is best to follow the order of procedure outlined below. First turn off the cylinder lubricator, so that the oil remaining in the cylinder may be consumed and none left to deposit upon the walls and gum up the piston and the rings. This should be done, if practicable, about five minutes before stopping the engine. Then turn off the ignition current and afterward the fuel. Turning off the current will leave an unburned charge in the cylinder, and if the piston is tight this charge may be employed for starting the engine the next time it is used. Finally turn off the water, and open the drain cocks when the weather is cold. If this precaution is not taken in winter, the water may freeze and burst the jacket. Finally try to stop the engine so that all valves are closed, i. e., during some portion of the compression or the expansion stroke. Otherwise the charge which is retained for starting the engine is likely to escape.

GAS-ENGINE TROUBLES.

Like any piece of machinery, and especially the prime movers, the gas engine is subject to derangements peculiar to itself and a knowledge of these and the remedies that apply is essential to the gas-engine operator. The writer will give them in tabular form for the greater convenience of reference. It should be noted that both gas engines and gasoline engines are included below.

ENGINE WILL NOT START.—Always examine the ignition system first, as 75% of the time the trouble lies there. To test the electric circuit, go over all the connections carefully and see that they are tight and not corroded. Then see if the current is leaking across anywhere so that it does not get to the igniter. This is known as a "short circuit." If it is a hammer-break igniter, hold the points together and detaching the wire from the insulated electrode rub the end of the wire on the end of the electrode. There should be a bright spark. If no spark is obtained there is a short circuit. Then hold the points apart and try again. If a spark is obtained the current is leaking through the igniter insulation. Should the ignition be by the jump-spark system see that the plug is clear of soot, or that it is not damp. A damp plug may be quickly dried by dipping it in gasoline and setting fire to it. It may be that the vibrator or the switch is fouled and will not operate. If there is an excessive spark at the vibrator it is a sign that it is in need of cleaning. Keep the vibrator and the switch clear of dirt and oil. The high-pressure wires should be kept away from pipes or metal parts of the engine. This is especially true of the wire that is attached to the plug. See that the fuel valve is not open too wide, as this would give too rich a mixture and it would fail to explode. In very cold weather, the engine or the vaporizer may be too cold. Either fill the water-jacket with boiling water or pour hot water on the vaporizer. Warm gasoline will often start a cold engine. See if the fuel supply is cut off in any way, and examine the fuel tank to see if it is empty. See if there is water in the gasoline. To test for water pour a little of the fuel on a flat metal surface. Gasoline will spread, while water will stand in globules. In a two-cycle engine it may be that the crank-case is flooded. Water may leak into the cylinder from the jacket, and prevent starting.

WEAK EXPLOSIONS.—The igniter may set too late, so that it has not sufficient lead. The fuel valve may not be open wide enough or it may be too far open. There may be a loss of compression due to leaky valves or a leaky piston, or even a leak through the cylinder wall or the gasket which is employed to pack the cylinder head. The starting lever may have been left in the starting position or the relief cock may be open. Leaks past the valves may indicate that they need regrinding or that the springs are too weak. In an engine using a suction inlet valve it may be that the spring is too stiff to allow the cylinder to get a full charge. The exhaust pipe may be obstructed with soot. Often soot will deposit in the muffler and cause back pressure.

EXPLOSIONS OCCUR IN THE MUFFLER OR IN THE EXHAUST PASSAGES.—In the first place, see if the igniter misses fire, as this is the usual cause of this trouble. Sometimes it is due to a leaky exhaust valve or one that is hung up by a weak spring. In hit-or-miss governing on the exhaust valve, the inlet valve may be drawn open during the idle strokes. If the latter is the case, the inlet valve should be arranged to lock during the idle stroke or an inward opening valve set in the exhaust pipe just where it leaves the engine. This will allow air to be drawn into the exhaust pipe and relieve the inlet valve of the suction due to the inertia of the exhaust gases.

ENGINE SLOWS DOWN AND STOPS.—This may be due to one of the causes outlined under Weak Explosions. Quite often it is due to an overload. The piston may be overheated owing to an insufficient supply of oil or to lack of water in the jacket. One of the bearings may be overheated.

PREMATURE EXPLOSIONS OR BACKFIRING.—Premature explosions are due to too early ignition. They may be caused by the igniter being set too early, to overheated air, to a hot cylinder, to projections of metal in the cylinder, or to deposits of carbon in the form of flakes or cones. The latter become incandescent and act in the same way as an ignition tube. In a two-cycle engine with enclosed crank-case, explosions will occur in the crank chamber when the fuel mixture is weak, or the igniter has too great a negative lead.

FLAME BLOWS OUT.—In engines with flame ignition, and especially of the Otto slide valve type, the trouble is usually due to a leaky slide. It may be from strong draft passing through the engine room. Should the flame of a tube igniter be blown out, there is probably a leak in the tube or in some surrounding part of the engine.

GRADUALLY WEAKENING SPARK.—The engine may start off well, but the spark may gradually become so weak that it fails to ignite. This is due almost always to a battery that is nearly run out. If the engine starts well and then misses explosions very often, getting an impulse when the speed slackens, the trouble is generally due to a loose connection. This connection is good so long as the vibration is not great, but so soon as the engine starts it is shaken loose and the circuit is broken.

POUNDING.—Look first for loose bearings. Then see if the charge is exploding prematurely. In a new engine it may be found that the piston is too tight, or it may become tight from overheating.

SMOKE.—Smoke at the open end of the cylinder is due to a leaky piston. In this case see if the cylinder is out of true, and, if so, have it rebored. Examine the piston rings to see that they are not stuck in the grooves and that they have a good bearing against all sides of the cylinder wall. See that they expand to bear snugly against the cylinder. Smoke issuing from the exhaust is a sign of excessive lubrication.

LEAKS.—Leaks between the cylinder head and the cylinder indicate the need of repacking. This should be done with sheet asbestos of good quality, not over 1-32-in. thick. Both surfaces should have a coat of orange shellac which has been dissolved in grain alcohol. A lead gasket may be used to advantage, and in an emergency, several thicknesses of well-oiled manila paper. To regrind a valve it is best to employ either pumice or rotten stone or grindstone grit. If flour emery is used it should be most carefully cleaned out after grinding.

GENERAL NOTES.

Never use a heavy lubricating oil for the cylinder, as it is apt to clog the ports and the piston rings. Always get an oil for this purpose that is made expressly for gas-engine cylinders. Never oil a valve stem with lubricating oil. Keep them clean and free from gum, occasionally squirting on a little kerosene. Don't use cells that are made for an ordinary door bell for gas-engine ignition. Get cells made expressly for this purpose or either caustic soda cells or a small storage battery of two cells. Don't use a long spark coil on a high-speed engine. A coil for an automobile or a marine engine should be not over six inches long. Feed the cylinder oil regularly and in small quantities, never by fits and starts. Keep gasoline pipes and lubricator tubes free from dirt. Always strain gasoline when pouring it into a tank. Separate water from gasoline by pouring it through closely woven muslin or chamois skin. Keep the engine clean, the wires tight in the binding posts, and examine the circuit frequently to see that it is in good order. Never operate an engine unless you have an extra battery of a sufficient number of cells on hand for an electric igniter or an extra tube on hand if it uses a tube igniter.

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

Perhaps the most instructive feature of the great flood at Kansas City described in this issue is the fact that the entire city with a population numbering nearly 200,000 was left without water or gas supply or street railway service for over twelve days because of the destruction of one span of the bridge which carried the supply main across the Kaw River. There are strong reasons against raising the grade of a highway or railway bridge higher than necessary, since every foot it is raised means additional work expended on every pound of traffic which passes over it. In the case of a bridge built solely to carry a water main, however, this objection disappears, and the "flow line" bridge whose failure caused such vast distress and loss at Kansas City might just as well have been built far above the flood level as where it was.

The experience of Kansas City also ought to be a warning as to the necessity of safeguarding by every means possible the main aqueduct supplying a city with water. In the vicinity of Boston recently, according to press reports, a large magazine of explosives has been found located only a short distance from a large water main taking the whole output of a pumping station. Such a situation demands prompt remedy.

Many of our readers who have known something of past conditions in the navy will recall the period only a few years past when a large proportion of the officers in the service were kept in the rank of lieutenant until they were gray-headed men. A somewhat similar condition now exists in the Naval Corps of Civil Engineers. This body of officers now numbers 31 and will in four months number 34; but the number of officers of higher rank than lieutenant is only 6, the same as when the corps was composed of only 10 men. Further, there are only 4 lieutenants, and all the rest have the rank of "junior lieutenant." At present these junior lieutenants have an average age of 32 years; but as their promotion comes only by retirement of those in advance of them, it is easily figured out that these men will continue to bear the juvenile rank of "junior lientenant" until they reach an age of 53 years, on the average. The three men at the foot of the list have the prospect of promotion to be lieutenants when they reach the age of 59 to 61!

It needs no argument to prove the absurdity of such a grading in the corps. Fortunately the pay of these officers is fixed by length of service and not by rank; but it need not be said that because of this the matter of rank is a small and unimportant one. If the traditions of the serivce are worth anything, then rank is an important matter, and as much to be regarded as a reward for the faithful service which an officer gives to his flag as is his pay. The assignment of rank in the corps rests entirely with the President; and that the matter of regrading the corps has not been attended to since the large increase in its numbers was made, is doubtless a mere matter of oversight. Certainly if these officers are given any rank at all in the naval service they should be given one corresponding to their age, experience and responsibilities. There is now in the corps a man 40 years of age, charged with the sole responsibility for the expenditure of over $2,000,000 worth of construction work and the care and maintenance of government property worth over $4,000,000, and he has the rank of lieutenant. The simple statement of such conditions is sufficient proof that a remedy is needed.

We have received from a well-known engineer some recent correspondence, which we print as follows, omitting only the names:

Jaytown, Pa., Aug. 27, 1903.

——— Engineering Co., ———, Ohio.

Gentlemen: We have decided to try a new plan to get our goods before the public. We are sending you a catalogue, showing the different special metal coatings. We realize that this plan will be much more expensive, but we think it will be more effective.

Our proposition is to allow you a commission on any paint which you may sell or any orders that we may receive through your recommendations. We will allow you a commission of 20 cts. per gallon on our —— coating, and 10 cts. per gallon on our —— brown and —— oxide.

Kindly let us hear from you and let us know what you think of this plan. All of these paints, we guarantee to be strictly first-class in every respect. They are not simply experiments, but have been tested for years and have stood the most severe tests and climatic conditions.

Awaiting your reply, we are, Yours truly,

Jaytown Paint & Varnish Co.

Our correspondent promptly replied to this letter as follows:

———, O., Aug. 29, 1903.

The Jaytown Paint & Varnish Co., Jaytown, Pa.

Dear Sirs: We have your letter of the 27th outlining a plan for the sale of your goods. As you ask our opinion of the proposition, will say that we heartily disapprove of it. Yours truly,

The —— Engineering Co.

How many other engineers received the same letter, we do not know; but if even a small percentage of them returned a reply of similar tenor to the one quoted above, the manager of the Jaytown Paint & Varnish Co. doubtless has a more accurate idea of the ethics and standards of the engineering profession than he possessed a few days ago.

At first thought, we were inclined to print the real name of the paint manufacturer with the above letter; but it is not improbable that he erred through ignorance rather than intention; in other words, he is probably one of the class who see nothing wrong in an engineer or architect accepting a commission on the goods that he recommends to his clients. That is, he *thinks* he sees nothing wrong; but if the shoe were on the other foot we doubt not his moral perception would be mightily clarified. If he were building a new factory and it were suggested to him that the architect he employed was in receipt of a commission from the firms supplying the roofing, the builder's hardware, the iron work and various other supplies involved in its construction, it is likely that a different idea of the "commission" business might be born in his mind. We may go even further and surmise that if the "new plan" of obtaining business brings such prosperity to the Jaytown Paint & Varnish Co. that it has to build a large factory (which we trust may not be the case), it is dollars to doughnuts that its owner will be careful *not* to employ an architect or engineer to whom he has been paying commissions for specifying his paint.

It is all very well to say that an engineer can be just as impartial in his choice of materials if he is to have a percentage of the cost of a certain brand to benefit his own pocket, but nobody pretends to believe any such thing except for the purpose of quieting their own conscience. Long ago it was written that a man cannot serve two masters, and the saying will remain true as long as human nature persists.

We are well aware that there are not a few who hold far easier ideas of commercial morality; but they are not the majority, and when they become the majority the foundation stone of all commerce and industry will be undermined. If the consulting engineer may sacrifice his client's interest to his own, so may the salaried engineer on a salary sacrifice his employer; so may the salesman and the buyer take their secret percentage on their sales and purchases; so may the officers of a concern fleece it for their personal benefit; so may the cashier take what comes to his hand. The plain, simple fact, known to every man of sense, is that all business is and must be based on trust. No sane business man will knowingly have any dealings whatever with a swindler or a thief, no matter how great an apparent profit may be offered, nor will he take such a man into his employment. When the time comes that men cannot be found who can be trusted, then business will cease to be done, for there will be neither security nor prospect of profit.

Another thought suggests itself in connection with the above letter: The Jaytown Paint & Varnish Co. has no scruples about sacrificing its customers' interests by bribing their trusted advisers. Will it have any greater scruples about sacrificing its customers in the quality of its products? To be sure it "guarantees its paints to be strictly first-class in every respect," but what does this guarantee amount to? We need hardly say that the essential clause in any paint specification, without which all other clauses are vitiated, is an honest manufacturer. Of course, there are a few consumers of paint, some of the large railway companies, for example, who are in a position to test their purchases and know, to some extent at least, what they are getting; but we are speaking now of the great mass of purchasers who buy paint at so much a gallon, spread it, and wait for the lapse of time to reveal its actual qualities. What security have these purchasers that the paint they buy is compounded of the best materials and not cheapened more or less by adulterations, except the general reputation of the manufacturer for honest and fair dealing.

A contemporary, while agreeing with us that the paved portion of a residence street can often be narrowed with advantage, takes the stand that this narrowing is best accomplished by moving the curbs closer together so as to leave 20 to 27 ft. between curbs. This is a practice that commends itself for very short streets where storm sewers exist, but it should seldom be adopted elsewhere. To narrow the distance between curbs to 20 ft. means virtually to make a gutter of the whole roadway wherever the street drains any considerable area. And in any case the water running along the curb of such a narrow street after a heavy rain would wet the feet of the pedestrian. Serious as is this objection to the placing of curbs 20 ft., or so, apart, there are several other objections. On a street where such a narrow roadway would suffice, a strip of macadam 16 ft. wide will ordinarily be found all that is needed to accommodate the travel; and if such a strip is laid on a street that is 36 ft., say, between curb lines,

there is often no necessity of any curb at all; for a curved sod terrace from the gutter to the sidewalk level is not only adequate and cheap, but more pleasing to the eye than a stone curb. Stone curbing seldom costs less than 40 cts. and often $1 per lin. ft.; so that to curb both sides of a street may readily cost even more than to lay a 6-in. pavement of macadam in the center of the street. This consideration is in itself a sufficient reason, in most cases, for rejecting the narrow paved way with curbs along the edge of the pavement; but there are still other reasons why the narrow macadam on a wide street is often to be preferred aside from these two of street flooding and cost. In the cities of states where irrigation is necessary to the growth of all vegetation, as in Ogden or Salt Lake City, Utah, the ditches at the sides of the street serve to irrigate the shade trees, and there it would be quite out of the question to move the curb line without moving the trees and the sidewalks also. Even in humid regions the watering that trees receive from nearby gutters is undoubtedly a factor in their growth.

In arguing against earth shoulders on the sides of a narrow macadam roadway it is generally assumed that this earth is always either muddy or dusty. But, as a matter of fact, sod will, and often does, grow on these earth shoulders right up to the edge of the macadam, in spite of the occasional turning out of a wheeled vehicle; and directly in front of houses where vehicles most frequently stop, it is perfectly practicable to lay cobble stones, macadam, or gravel up to the curb line. Shale too poor to make a wearing coat for the center of the street can also be used for the shoulders, as exemplified in a design shown elsewhere in this issue. Earth when constantly churned up by passing wheels and hoofs becomes bottomless mud, but when subject to occasional rolling of wheels, as in a street where the center is paved, the earth never becomes so saturated with water. This is a fact constantly ignored by the theoretical advocate of the necessity of a curb to curb pavement.

Finally there is a condition that the engineer may ignore in discussing the relative merits of different street designs, but a condition that the engineer having charge of street work cannot ignore. We refer to the stubborn and often unreasoning opposition on the part of property owners to any proposed shifting of the curb line. The smaller the town the more stubborn this resistance is apt to be. The objection may be raised that a 20 or 24 ft. street will be blocked by every unloading coal wagon; or it may be argued that the increased sodded area made by moving the curbs out is an increased care that it is not desired to assume; or any one of half a dozen reasons may lead to opposition to the proposed change. Here is a condition of the kind that so often confronts the engineer, and one that he must recognize in designing public works where the public has a voice.

Of the many good papers presented at the Montreal convention of the New England Water-Works Association, last week, and abstracted elsewhere in this issue, particular attention may be directed to two, both because of their intrinsic value and because they indicate the desirability of more work in the same fields. The paper on the use and waste of water in the public schools of Syracuse, N. Y., recounts one of a number of recent attempts to place the responsibility for the waste of water upon municipal departments. It has long been known that immense quantities of water are wasted in public school buildings, but the investigations at Syracuse are of both local and general value in showing how great that waste sometimes is. In one school the average daily consumption per pupil was 497 gallons in the month of March, 1903, while in a number of others it was below six gallons, and in one case was only 2.3 gallons. A meter on every school building, and payment for all water above a reasonable quantity, was suggested by the author of the paper; but why not payment for all water, so the school department will bear its portion of the public burdens?

The other paper to which it is desired to call particular attention is the one on tests of 6-in. water meters at Knoxville, Tenn. These tests add largely to the small amount of information previously available on the reduction of pressure by large meters when passing water at high velocities. They also contribute materially to the data on the sensitiveness of large meters to the flow of small streams. The tests were made at no little expense by a private water company, and similar ones are to be instituted at Burlington, Vt., by a municipal water department. Announcement was also made at the convention that one or more new and improved devices for measuring heavy flows of water are about ready to be placed before the public. It is only a question of time before the bulk of the water consumed and wasted in every city will pass through some form of meter, and consumers will pay for water by measure instead of by guess.

PANAMA OR NICARAGUA?

A little more than a year ago, following the passage of the Isthmian Canal Bill by Congress, on June 26, 1902, we said editorially:

> Congress has decided upon the Panama route. There is still the bare possibility that either the New Panama Canal Co. or the unstable Colombian Government may fail to give the United States a satisfactory title, in which case the President is to undertake the work at Nicaragua instead. This possibility however, is doubtless very remote; and we may confidently look forward, now that the responsibility is placed on the Executive Department, to rapid progress toward the actual undertaking of the Panama work.

What we then alluded to as "a bare possibility" has recently become a strong probability. During the fourteen months which have elapsed since the passage of the canal bill by Congress, the State Department has completed its examination of the title given to the United States by the New Panama Canal Co. of France and has drafted a treaty with Colombia which has been ratified by the Senate. The only thing still remaining to be done to enable the United States to immediately proceed with construction at Panama is the ratification by Colombia of the Hay-Herran treaty, and the prospects for such ratification appear to grow less with every passing day. The treaty was signed by Messrs. Hay and Herran on January 22 last, and according to its terms, "ratifications shall be exchanged at Washington within a term of eight months from that date." That is to say, before September 22 the ratification of Colombia should be filed with the State Department at Washington or the treaty will fail. Even if the Colombian Senate should now ratify the treaty as originally drafted, it would be impossible to file the formal papers at Washington before Sept. 22. Doubtless, however, the informality would be waived and the ratification would be accepted if the Colombian Senate should see fit to make it at any time before Sept. 22; but is there any prospect that it will take such a step? If the current press reports from Bogota are to be trusted, there is little chance that this will take place. The Colombian legislators and its public generally appear to be under the delusion that their country possesses the only possible canal route across the isthmus; that the United States must and will take it at any price, and consequently that they can make the terms and conditions what they please. On Sept. 14 the Colombian Senate was said to be discussing a bill fixing the price of the canal concession at $20,000,000 and making various other radical changes in the terms fixed by the Hay-Herran treaty.

To say that such talk of a new treaty or of alterations in the Hay-Herran treaty is idle is to put it very mildly. Public opinion in the United States would absolutely not countenance any alterations in the Hay-Herran treaty at the dictation of Colombia, even if our State Department were disposed to grant them or the Senate to approve, and there is no sign that either of these conditions exist. In fact anyone who recalls the strenuous work through which the Panama bill was finally carried through Congress and the approval of the Senate to the Hay-Herran treaty was finally secured will admit that the Panama route must stand or fall on the approval by Colombia of the Hay-Herran treaty without the alteration of a single comma. Anything which would require the treaty to be submitted again to the United States Senate would mean its utter failure. In fact the public generally has been so disgusted with Colombia's general demeanor on the canal question that it is probable that if Congress had to-day to decide the question of rival routes over again, with Colombia's approval of the Hay-Herran treaty assured beforehand, it would vote in favor of Nicaragua.

Under the terms of the Isthmian Canal Act, however, the President has no need to refer the matter again to Congress. Instead, that law specifically instructed him that if unable to obtain the necessary authority from the Panama Canal Co. and from the Colombian Government within a reasonable time and on reasonable terms, he should then proceed to construct a canal at Nicaragua. That clause of the law is as valid and binding as any other, and under it the President has no option but to proceed with the work of completing the necessary franchise rights for a canal at Nicaragua, and with its construction when those rights are secured. It may be said that the President has the power to decide what are "reasonable terms" and a "reasonable" time; and he may elect to give Colombia a longer period of time. The President's action, however, will doubtless be governed by what he knows the temper of Congress to be. It would be of no use for the State Department to concede better terms to Colombia unless Congress approved the concession, which there is not the slightest prospect it would do. Again, even if the President were disposed to grant more time to Colombia, he is limited by the terms of the treaty itself, and after Sept. 22 the assent of Colombia will be of no avail. It would be necessary then to draft an entirely new treaty, which would have to run the gauntlet of the Senate of both countries with defeat certain at the outset. Under these circumstances what is there for the President to do but proceed with the Nicaragua route?

Of course it will be understood that here, as at Panama, the work of the diplomat must precede that of the engineer. Treaties with Nicaragua and Costa Rica must be negotiated and approved by the governments of both countries. The preliminary steps for such treaties were taken two years ago, however, and their completion should be a matter of a short time.

It is not to be doubted that the abandonment of the Panama route and the taking up of the Nicaragua route again will be accompanied by a new warfare against the Nicaragua route on the part of a certain section of the daily press. Yet the relative merits and demerits of the two routes were so carefully and impartially set forth in the report of the Isthmian Canal Commission three years ago that there is little excuse for such intemperate utterances as are frequently found in print from the advocates of each side. The fact is, as every impartial student of the matter is aware, that a ship canal entirely satisfactory for all purposes can be made at either Panama or Nicaragua. Each has certain advantages and certain disadvantages; but the balance is so nearly even that the Isthmian Canal Commission recommended Nicaragua at first rather than pay the excessive price originally demanded by the Panama Canal Co. for its rights.

The Nicaragua route presents no single works of as great magnitude as those at Panama. The Conchuda dam presents less difficulties than that at Bohio, and will cost only two-thirds as much. The long divide cut at Nicaragua contains 18,000,000 cu. yds.; the Culebra cut at Panama contains 43,000,000 cu. yds. The water supply at Nicaragua is a natural lake and is unlimited in quantity. At Panama it would be an artificial lake. The time required to pass through the canal would be 33 hours at Nicaragua against 12 hours at Panama; but this is only of importance so far as it increases the total length of voyage; and, to quote the Isthmian Canal Commission:

> The Nicaragua route is the more advantageous for all transisthmian commerce except that originating or ending on the west coast of South America. For the commerce in which the United States is most interested, that between our Pacific ports and Atlantic ports, European and American, the Nicaragua route is shorter by about one day.

We believe this advantage of the Nicaragua

route is worth larger emphasis than it has ever received. One source of traffic for the Isthmian canal, which has scarcely received notice in the past, is now looming larger than ever before. We refer to the export of lumber from the forests of the North Pacific coast to the Eastern United States and to Europe. The greatest body of uncut timber lands still remaining on the globe is that which stretches from San Francisco to Alaska. To it during the next score of years all the world will turn for a timber supply, and it would not be at all surprising if the lumber shipments through the Isthmian canal when completed would dwarf all the rest of its commerce. Should this be the case, there would be a great advantage in having the canal at Nicaragua rather than Panama.

There is another great advantage of the Nicaragua route which we cannot but feel has been underrated in the past, at least in popular opinion, and that is its comparative hygienic advantage. Panama is and has been from time immemorial a plague spot, while Nicaragua has enjoyed comparative immunity from disease. One great reason for this is found in the constant trade winds which sweep across the isthmus at Nicaragua, while Panama is in the region of calms. It is not too much to say that the choice of Nicaragua instead of Panama means the saving of thousands of lives; perhaps of tens of thousands. It is not alone the loss of life during the years while the canal is under construction, great and deplorable as this might be. We must look forward to the years to come, when the canal is in operation, when the United States will have to maintain a permanent establishment on the isthmus, when population gathers along the canal and cities are built at its terminals. It is worth much to the world that new centers of population should be established in places free from such infection as has its hotbed at Panama. Particularly is this the case when commerce is to go out from it to every quarter of the globe. What a handicap to a canal's usefulness it would be if at frequent intervals ships passing through it had to suffer long detention in quarantine. If the canal is to bring so large a traffic to and from our seaports as is prophesied, then it is worth while to have it located where sanitary conditions are the best and where cities in the United States will not be in constant danger of having tropical fevers brought to their doors.

The construction of a canal at Nicaragua means a larger expenditure, according to the estimates of the commission; but this additional expenditure is about covered by the sum proposed to be paid to the Panama Canal Co. It involves a greater amount of work than a canal at Panama; but the works are of less magnitude than those at Panama, and present on the whole fewer engineering difficulties.

On the whole, therefore, we see no reason for particular disappointment if the short-sighted Colombian legislators shall reject our offer for the Panama franchise. The nation can proceed now to build a canal to Nicaragua and can have the satisfaction of proceeding on virgin ground and not undertaking the completion of a project which had been in former years indelibly branded with failure and dishonor.

LETTERS TO THE EDITOR.

Sun Printing from Blue Prints.

Sir: The writer has, on several occasions, found it desirable to make a copy of a blue print, the tracing not being available. He used the blue print in precisely the same manner as a tracing is used and sometimes obtained fairly good results, but only when the original print was a good one and the paper was thin. Is there any method by means of which good prints may be obtained from blue prints, possibly with the aid of chemicals?

Yours truly, Young Engineer.

Cincinnati, O., Sept. 7, 1903.

The Use of V-Bents for Squaring up Curves in Viaduct Work.

Sir: In your description of the New York Rapid Transit Elevated Structure (Eng. News, Sept. 3, 1903), you make special mention of the V-bent. Several years ago in carrying one railway line over another and under a third, all tracks being on curves, and both crossings between 40° and 45° skews, the writer used this same construction for the purpose of squaring up the ends of his steel trestles, and found it very satisfactory indeed.

Yours very truly, J. I. Boggs.

Little Rock, Ark., Sept. 7, 1903.

Soundness Tests of Portland Cement.

Sir: Referring to the letter of Mr. P. C. McArdle in your issue of Sept. 3, I trust we may hear more from him on this late deterioration of cement, and from others who may be able to throw light on the matter. We have recently had similar experience with a certain brand of cement and it is puzzling. Our tests for fineness gave 95% and 98% through a 100-mesh sieve, and breaking results as follows:

	Sample 1.		Sample 2.	
	Neat.	1 to 2.	Neat	1 to 2.
24 hours	218 lbs.	...	473 lbs.	...
7 days	738 "	284 lbs.	754 "	452 lbs.
28 "	695 "	335 "	777 "	430 "
53 " .....disintegrated		sound	...	...
65 "		...	disintegrated	sound

The briquettes had been kept immersed in water continuously. Yours truly,

T. H. Loomis,
Div. Engr., Pittsburg, Toledo & Western R. R.

Steubenville, O., Sept. 7, 1903.

Is Mica Objectionable in Concrete?

Sir: Will you kindly inform me through your paper the results of using in concrete, sand or rock which contain mica, and oblige, very truly yours,

F. N. Fowler, Jr.

Bulls Bridge, Conn., Sept. 3, 1903.

[We can find no record of strength tests of micaceous sand other than those given in our issue of Aug. 6, in "The Report of the Commission of the Jerome Park Reservoir." The report gives tests of mortar made of stone dust containing a "very little mica." The stone is a micaceous schist, and to the eye the screenings appear to contain a large percentage of mica. Since the flat flakes of mica reflect the light and catch the eye, it does not require much mica to give an appearance of abundance. To put a definite percentage of mica in a sand and then to test the strength of the mortar made with it would be a simple matter, but we know of no such tests. —Ed.]

Technical Education of Apprentices.

Sir: In every country this is becoming a very interesting and most important subject. It may be interesting to you to know that as far as this country is concerned I have started a new system in regard to encouraging our apprentices to take up technical classes.

The following is briefly the scheme which has been adopted at these works in Derby: We have arranged to pay half the fees, and purchase the necessary instruments and books for all our apprentices who take advantage of the evening classes at the local technical college in approved subjects, for a term of three years. Every apprentice passing the examination at the end of each year will receive increased wages per week, and those apprentices who pass all the examinations will be allowed to retain the instruments purchased for them.

I should be grateful to you if you would kindly give me any information in regard to what is being done in the United States in regard to this subject, especially on the following points, viz.:

(a) The system pertaining to apprentices in engineering works, both private and government.

(b) What effort is made by employers in these two classes to promote the technical education of their apprentices; their attitude; the course followed and the results obtained. Yours faithfully,

Andrew Handyside & Co., Ltd.,
Edw. E. Mathews, Works Mgr.

Derby, England.

Wanted: A Non-Corrosive Pump for a Salt-Water Aquarium.

Sir: We are building an aquarium in which there will be an exhibit of salt-water fish and in the operation it requires the salt water to be pumped. The pipes used are lead lined. The only kind of a pump that has been used for this purpose hitherto is of hard rubber or nickel, which is very expensive, and the question arises as to whether or not red bronze metal could not be used for the pump. The question is whether or not the red bronze metal will have any action upon the salt water detrimental to the fish. Some experts say that it will gather and throw off salts which would be detrimental to the fish as the water necessarily will be a closed circulation and will pass many times through the pump. The red bronze metal mentioned is what the government uses for valves in the navy department. Very truly yours,

M. P. H.

Detroit, Mich., Sept. 8, 1903.

[We should think there would be much danger that from any form of bronze, copper or zinc salts would be dissolved in the water and poison the fish. It ought to be possible to so lay out the plant that an air-lift pump could be used to circulate the water; and such a pump would have the particular advantage that it would thoroughly aerate the water every time it passed through the pump.—Ed.]

The Dimensions of the Budapest Bridge.

Sir: Referring to a letter by Mr. Gustav Lindenthal in your issue of Aug. 13, I desire to correct several statements there made in relation to the dimensions of details given as those to be found in the Budapest chain (not eye-bar) bridge.

The Budapest bridge is not an eye-bar bridge in any American sense of the word. It is clearly and specifically a plate-chain bridge. In the United States an eye-bar is never anything but a bar with a head, either forged or welded, at each end. The chain links of the Budapest bridge are rolled plates with heads milled at either end and the width of the bars between eyes cut away to remove the unnecessary material. The strength of an eye-bar is a very doubtful matter. The strength of plate-chain links is subject to very little doubt, and is very uniform. The strength of eye-bars is anything but uniform.

Mr. Lindenthal states that the Budapest bridge has a span of about 1,000 ft. It is only 950 ft., or 5% less. He states that the links are "19½ ins. wide and 1½ ins. thick." There is not one bar in that bridge 1½ ins. thick; there is nothing thicker than 1 in. used in any part of the bridge. The widest bars used in the chains are 19 ins. × 1-in. × 35 ft. long; but while 502 have about this width there are about 2,700 of a width of 17 ins., a thickness of 1 in., and a length of about 36 ft. On the other hand, in this bridge there are 220 bars 43 ins. × 1 in. × 13 ft. long used in the anchor chains and back stays.

There is all the difference in the world between forged eye-bars 2 ins. thick and rolled plate links not over 1 in. thick. The difference as to reliability and knowledge of strength is as day is to night. Gus. C. Henning.

275 Water St., New York City, Aug. 14, 1903.

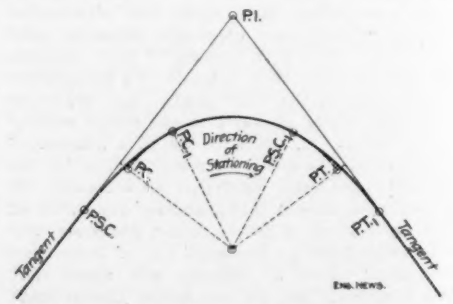
(We know of no reason why eye-bars made according to the American plan under up-to-date specifications are not equal in quality to eye-bars made by cutting the bar out of the rolled plate—a method of manufacture which will strike the average American engineer, we believe, as being expensive and wasteful.—Ed.)

Standard Forms of Lettering Points on Transition Curves.

Sir: In your issue of Aug. 27 a correspondent calls attention to the absence of any standard form for designating the critical points on a spiraled curve, and submits a sketch illustrating what he considers would be a good standard to be adopted.

While it would be convenient, as well as beneficial, to have a uniform method of lettering the points on a spiraled curve, I do not think that such a reform can be expected very soon, as the matter is not considered of sufficient importance to demand general attention, and there is also too much difference of opinion as to what really is the best method.

I would prefer the form of lettering shown on the accompanying diagram. It is that used by Prof. C. L. Crandall, of Cornell University, in his work on the railroad spiral, except that here P. S. C. and P. S. C_1. are used for the beginning of the respective spirals, instead of P. T. C. and P. T. C_1., as used by Prof. Crandall. This change does away with the letter T., at all points, except where "Tangent" is an element, and substitutes the word



Suggested Standard Form for Lettering Points on Transition Curves.

spiral for transition, the former being shorter and as easily understood as the latter.

As the additional points involved in a curve with spiraled ends signify elements similar to the points of a simple curve, I think these additional points should be designated as far as is practicable, by using abbreviations having a like similarity, and to reach this result, I see no especially undesirable feature in using three letters, nor in the sub-numerals.

My objection to your former correspondent's method lies in the fact that the abbreviations used differ too much from those in general practice for a simple curve.

Yours truly, S. M. W.

Cedar Rapids, Ia., Sept. 2 1903.

The Value of a Farmer's Advice on Railway Location.

Sir: An article upon location that appeared in your issue of Aug. 20, contains the following sentence:

Where accurate maps cannot be obtained, there is no source of information of more general value than the men who have worked for long periods in the district, and have had years in which to learn what the engineer is usually expected to acquire in a few weeks.

The value of this class of information is always open to suspicion of self-interest, and a recent experience of the writer's confirms this once more. While locating a light railway in very heavy country, at one creek crossing he cut the extreme lower edge of an "Engineer-Farmer's" farm, and obtained an excellent crossing of a very bad creek, using however his maximum to get down. A few days after making the location he was taken somewhat aback by the E.-F. (he claimed to be both engineer and farmer), coming to him and telling him that he had missed his route entirely, that half a mile further up stream was a long ravine presenting a much easier gradient and less curvature than the one he came down. The writer was at some loss to understand how he could have missed such favorable conditions, as he was under the impression his reconnoissance very thoroughly cove.ed the area alluded to. However, the man had lived in the country for 30 years, besides making some claims to being an engineer, and as the entire area was very densely wooded, a second reconnoissance was certainly in order. After a week of very tiresome investigation, the topography being very rugged, the writer came to the conclusion that there was nothing whatever in the statement, and instead of getting down with less than his maximum, that he would have to use considerably more. Pressing the E.-F. for his reasons in wanting him to go higher up, at the same time politely telling him the line would be built as first located, the writer was somewhat astonished when the farmer confessed that he feared the construction of a bank along his lower line, for the creek might (?) rise and flood his farm, and if built along the upper line it would act as a levee and protect him. So much for this class of information.

Yours very truly, J. I. Boggs.

Little Rock, Ark., Sept. 7, 1903.

Is the Use of an Iron Follower or Cap on Piles to be Recommended?

Sir: Will you kindly give us your opinion on the efficiency of a 1,200-lb. hammer, used in connection with an 800-lb. cast follower, resting on the head of the pile, in driving ordinary pile bridges, as compared to a 2,000-lb. hammer without follower, and using same length of leads?

We are hoisting hammer by steam. Shall be must obliged for any information on the subject.

Yours truly, Samuel Young.

Pascagoula St. Ry. & Power. Co.,
Scranton, Miss., Sept 7, 1903.

[An iron follower is used primarily to protect the heads of soft-wood piles, or of hard-wood piles that are to receive severe battering. Incidentally a cap or follower saves a small amount of time in ringing a pile and in taking off the ring after the pile is down; but this time saving is so slight as not to deserve consideration. These are the advantages due to the use of a cap; but, on the other hand, the penetration of a sound pile with a cap on is much less under each blow than it is without a cap, despite the statement in Baker's "Masonry" that the cap "adds to the effectiveness of the blows." It is evident that in making the foregoing generalization, Professor Baker had in mind the saving of the head of the pile from brooming, for brooming unquestionably does decrease the penetration under each blow. So long as the wood will stand up under the driving, a 2,000-lb. hammer, striking a banded pile head direct will be far more effective than striking with a 1,200-lb., or even a 2,000-lb. hammer, on an 800-lb. cap. A member of our editorial staff once had occasion to use a cap in driving oak piles, but soon abandoned the cap to return to the old method of ringing the pile heads. Against ringing the heads it is sometimes argued that time is lost in removing the ring, and that the life of the ring is short; but these objections are not founded on carefully kept records of cost. A pile once in the leaders may be struck as many blows without ringing as it will stand, then it takes less than a minute to raise the ring, place it, and drive it down upon the champfered pile head. To remove the ring an iron cant-hook or pevee should be used, and by fastening the pile-raising rope to the end of this pevee, the ring is removed by the engine; the time so consumed being half a minute, ordinarily. As to the life of the rings themselves some valuable data are to be found in our issue of Oct. 27, 1898, p. 271, where it is stated that each ring made of 1 × 3-in. bar iron was rendered useless after driving 50 oak piles, or 200 cedar piles; whereas rings made of old car-axles lasted 50% longer. Since each ring costs about $1.75 we see that the few cents chargeable to each pile for wear and tear of rings is a negligable item, as above stated.

For driving the softer pines, and softer woods generally, the cap undoubtedly has its field of usefulness, and possibly some of our readers may know of other conditions under which it is truly economic to use pile caps instead of pile rings. —Ed.]

PROPOSED ROADWAY CONSTRUCTION FOR HAWS AVE., NORRISTOWN, PA.

Efficiency of High-Head Impulse Wheels—A Correction.

Sir: We notice in your issue of Aug. 6, p. 121, a note on the efficiency obtained by impulse water-wheels operating under a high head in the Redlands plant of the Edison Electric Co. of Los Angeles, Cal. The impression that would be produced on reading this note is that the Pelton wheel was lacking in efficiency. We feel sure that you would not knowingly mislead your readers in regard to this point, and we therefore take pleasure in stating that the Pelton wheel at the above station showed in the efficiency measurements which were made by independent engineers, an efficiency of 86.2%, whereas the efficiency of the other type of wheels was materially below this amount. These tests were conducted by Mr. Sam'l Starrow, of the Douglas Building, Los Angeles, and Prof. L. M. Hoskins for the competing wheel, and by Prof. J. N. Le Conte, of the University of California, for the Pelton wheel. The results of the measurements made by these gentlemen on both wheels, as well as the experience of the Edison Electric Co. in the regular service operation of these wheels, has demonstrated beyond a doubt the superior efficiency obtained by the Pelton.

Furthermore, part of your statement reads:

We are informed by the Abner Doble Co. that they furnished one wheel on the first order, and that the results of tests on this wheel in competition with the Pelton wheel gave them the contract for the other two wheels.

I am authorized by the Edison Electric Co. to positively state that such orders for water-wheels as they have placed with the Abner Doble Co. were placed before any competitive measurements of any sort or kind were made.

We trust you will do us the justice of publishing these statements so that there may be no misconception in the minds of your readers in regard to the results obtained from our wheel. Yours very truly,

Geo. J. Henry, Jr.,
Chief Engineer, Pelton Water-Wheel Co.

New York, Aug. 21, 1903.

(The note which appeared on page 121 of our issue of August 6, 1903, was prepared from a two-page typewritten statement sent us with an accompanying letter by the Abner Doble Co., of San Francisco, Cal. This statement contained the following passage:

The plant to be installed by them (the Edison Electric Co., of Los Angeles.—Ed.) was to consist of four water-wheel generating units of 750 KW. each, designed for a 25% overload, at a turning speed of 430 r. p. m. They therefore decided to install at first but two units, the balance of the plant to be placed with the engineering firm furnishing the most efficient and satisfactory wheel unit. Accordingly they placed an order for one unit with the Pelton Water-Wheel Co., of San Francisco, the order for the second unit being placed with the Abner Doble Co., San Francisco, makers of the Ellipsoidal Tangential Water Wheel, at the same time taking an option from each firm for two additional wheel units, with the agreement that the order for the additional wheel units would be placed with the engineering firm furnishing the wheel unit of the best engineering design, workmanship, efficiency, and giving the most satisfactory results when in operation.

The initial wheel units have been installed and tested, and have been in operation for several months, and it is interesting to note that, based on the results secured from these two wheel units, the Power Co. exercised their option, placing the order for the balance of the wheel units with the Abner Doble Co., on account of the high efficiency over a wide range of load shown by their wheel, its capacity to carry a very heavy overload, and the maintenance of this high efficiency over a wide range of load.

Mr. Henry in the letter printed above directly contradicts certain essential portions of the passage just quoted. We have referred the matter to the purchaser of the wheels, the Edison Electric Co., of Los Angeles, who in a letter to us confirms the assertion of Mr. Henry. We have sent copy of Mr. Henry's letter to the Abner Doble Co., asking them for an explanation, but have received no reply.—Ed.)

Design of a Macadam Strip With Shale Shoulder for a Street in Norristown, Pa.

Sir: I enclose you a sketch of the cross-section of Haws Ave., Norristown, Pa., as we propose to construct it. This avenue will not receive heavy traffic. It is really a residential street, with only one store on it and that is located on the corner of a cross street, which will not necessitate driving on the red shale. I have constructed several roads in our suburbs of red shale, using a high crown and rolling with a 15-ton roller, and have had excellent results. We have also used loose field stones, covered with shale and rolled, which gave several years' wear. When the ordinary method of "fixing" a county road is compared with this we certainly show much better and more lasting results. Yours truly,

S. C. Corson, Borough Engineer.

Norristown, Pa., Aug. 26, 1903.

[It will be noticed that Haws Ave. is not only very wide (100 ft.) between property lines, but that the distance between curbs (50 ft.) is greater than is ordinarily needed on a residence street. In fact if it were practicable to move the curbs out so as to reduce the width to about 36 ft., the cost of street improvement and maintenance would be considerably reduced. The question of moving curbs so as to narrow the roadway is editorially discussed elsewhere in this issue, so that further discussion here would be a repetition.

The use of shale for the shoulders on each side of a trap-rock wearing coat is an excellent design. Shale, in many cases, does not require crushing in a rock crusher, since a 10-ton roller effects the necessary crushing and the rolling at the same time. Hence these shale shoulders may be almost as cheap as gravel shoulders even, where the hauls are equal; and in some Pennsylvania towns in the coal regions the shale waste from mines may be had for nothing.

Gravel shoulders are often used where a 16 or 18 ft. of macadam is laid down the center of a street, and an excellent curb to curb roadway is thus secured at moderate cost.—Ed.]

A Macadam Strip in a Village Street.

Sir: Your remarks appended to my letter in your issue of Sept. 3 have been duly perused, and I wish to state that I did not mean to have my words construed as a general condemnation of macadam pavement for a residence street in a city, but a disapproval of paving such a street with a narrow strip of macadam through the center. In fact, the same kind of macadam, built by the same man on the same subroll in another street, but paved from curb to curb, gave entire satisfaction and made a very pretty, clean and attractive street.

I still fail to see how you intend to build a macadam

pavement to prevent it from being continually broken down on the edges and worn off, when there is nothing to protect it but a softer material that becomes all cut up in wet weather and ground to dust in dry weather; for if the material on the side is hard enough to protect the macadam it is hard enough to pave the street with. Then again, how do you intend to confine the driving to the center? It must be admitted that the greater part of the driving done on a residence street is done on the sides, besides a continual crossing to and fro, differing entirely in this respect from a country road.

As regards the desired data of the street mentioned in my letter of Aug. 25, I will say that the subsoil is a reddish yellow clay; the thickness of the finished macadam was 8 ins.; the binder was of limestone screenings over a hard limestone base, rolled with two steam rollers, one 10-ton and the other 20-ton; the strip was 16 ft. wide, with a 9-in. crown, the earth sides being carried down at the same rate; and all drainage was carried to the side drains, no drains being laid under the pavement.

Yaurs truly, John Wm. Ash,
Asst. Engineer Southern Railway Co.

Rapidan, Va., Sept. 5, 1903.

(Regarding our correspondent's fear that the sides of a narrow macadam strip will crumble away under the action of wheels passing from the solid macadam to the soft earth shoulders, it may be replied that the fear seems to be unfounded, although our correspondent is not alone in having predicted failure from that cause. On a suburban street in Rochester, N. Y., where there was a great deal of pleasure driving, the macadam was curbed with oak plank set on edge to prevent the mingling of the macadam and the sandy shoulders, and this same practice has been followed elsewhere. But when this plank curbing rots away it is found that, contrary to prediction, the macadam does not crumble away at the edges. On the streets of Rockaway Beach, N. Y., where strips of macadam are seen with sand shoulders, there is none of the predicted disintegration of the macadam by crumbling, and the same holds true of macadam strips in the sandy portions of Orange, N. J., and elsewhere. On one of the suburban macadam roads of Buffalo, N. Y., where the soil is a red clay, there is a far greater traffic than most residence streets have to carry, and the wheel tracks show a frequent turning off of vehicles onto the clay shoulders, still there has been no disintegration of the edges of the macadam. Some of the macadam streets of Montclair, N. J., have shoulders of red clay that has not been the cause of crumbling away of the macadam at the sides. Indeed, like many another prediction concerning the probable failure of a narrow macadam pavement on a street, this one of crumbling away at the sides in practice proves to be unfounded.

As to driving on the center, the crown of the street makes that the most pleasant place to drive, aside from the desire to avoid dust or mud on the sides.

As to the suggestion that earth hard enough for the shoulders is hard enough for the entire covering of a street, it must be remembered that the earth may be hard enough to carry an occasional wagon turning onto it and yet not hard enough to carry continual travel in all weather.

As regards the failure of the macadam strip cited by our correspondent, the design appears to have been good, except that a side slope of more than one inch to the foot is excessive. We have known even 8 ins. of limestone macadam to fail on a country road where the subsoil was clay undrained except by side ditches. Such failure on clay is most apt to occur where construction is carried on during wet weather, or where excessive watering is done in puddling the screenings.—Ed.)

STATISTICS OF STREET AND ELECTRIC RAILWAYS IN THE UNITED STATES

The U. S. Census Office has issued a bulky report on the street and electric railways in the United States for the year ending June 30, 1902. This report includes all electric railways, irrespective of their length and location; and all street railways, irrespective of their motive power. At the census of 1890, the railways using motive power other than steam were confined almost exslusively to urban districts, and were properly classed as "street railways." The introduction of electric power has enabled these roads to extend their lines into the rural districts, and a large proportion (over one-third) of the trackage is now outside the limits of cities, towns or villages. In truth, the use of electric power has been the principal factor in the development of these railways, which now form a class of their own, distinct from street railways and ordinary steam railways. The use of electric power was reported in 1890 by 126 companies, with 1,262 miles of track; in 1902, there were 747 companies, with 21,920 miles of track. Table I. gives particulars as to mileage and operation.

TABLE I.—Street and Electric Railways in the United States, 1902.

	Miles.
1st main track	16,652
2d " "	5,030
Sidings and turnouts	908
Total track	22,590
Operated by overhead trolley	21,303
Other electric power	611
Compressed air	6
Animals	259
Cable	241
Steam	170
Trackage owned	19,039
Trackage leased	3,551
Built and opened in 1902	1,550
On private right of way	3,802
Within city limits	*13,208
Outside city limits	*6,856
No. of companies	987
Cost of construction and equipment	$2,167,634,077
Capital stock issued	$1,315,572,960
Funded debt outstanding	$992,709,139
Earnings from operation	$247,553,999
Operating expenses	$142,312,597
Operating, percentage of earnings	57.5 per cent
No. of passenger cars	60,290
No. of fare passengers carried	4,800,554,438
No. of employees†	133,641

*Exclusive of Massachusetts.
†Exclusive of salaried officers and clerks.

The number of companies operating more than 50 miles of line increased from 8 in 1890 to 69 in 1902, while the average length of line per company increased from 7.41 miles to 20.38 miles. The decrease in the length of line operated by animal, cable or steam power has, in every instance, been accompanied by more than a corresponding increase in the length operated by electricity. The North Atlantic States contain nearly half the total mileage of the United States, and in 1902 their railways operated more than half the mileage, carried more than half the passengers, and had more than half the employees. The North Central States rank next. The change in the character of the motive power has also been most pronounced in the North Atlantic States, where the miles of line operated by animal power decreased from 1,659 miles in 1890 to 66 miles in 1902. The number of rides per inhabitant of the United States averaged 63 in 1902, an increase of 31 over 1890. In the North Atlantic States the average number of rides per inhabitant was 124; South Atlantic, 32; North Central, 51; South Central, 15, and Western, 74.

Of the income, pasenger fares represented 94.5% Of the operating expenses, 8.5% was maintenance of way and structures, 11.7% for maintenance of equipment, 16.2% for operation of power plants, 43.9% for operation of cars, and 19.1% miscellaneous.

In track construction, the weight of rails ranged from 15 lbs. per yd. (at Paso Robles, Cal.) to 135 lbs. (Philadelphia). Of 817 operating companies, 367 use T-rails exclusively, and 390 reported T-rails in connection with girder and grooved rails. About 1,643 miles had cast-welded joints. There were 4,481 crossings of steam railways, of which 56.1 were protected by separating the grades or providing gates, watchmen or alarm bells. Of 21,920 miles of single track operated by electric power, 97.2% used the overhead wire; of this, 64.5% was supported by span wires, 32.9% by side bracket poles and 2.6% by center poles. Wooden poles were used on 80.4% of this mileage, and steel or iron poles for 19.6%. There were 16 miles of line having wires supported by elevated railway structures and by buildings and bridges. Only six companies reported the use of the double overhead trolley system, with 22.69 miles of track.

There were 6,547 miles of electric duct, occupying 589.3 miles of street. Of this 3,905 miles were of terra cotta and vitrified clay, 1,981 miles of iron pipe, and 660 miles of wood or other material. The use of underground construction predominates in Washington, Chicago, New York, Boston and Philadelphia. These five cities contain 5,423 miles, or 83.4% of the total for the United States.

In car equipment there were 66,784 cars of all classes, 60,290 being passenger cars and 6,494 for express, work, or other purposes. The use of express, freight or mail cars was reported by 295 companies, the largest number (209) being shown by the St. Louis & Belleville Electric Ry., which operates an interurban freight line between East St. Louis and Belleville, Ill. There were 127 snowplow cars and 793 street sweeper cars. There were 50,699 cars provided with electric equipment, or 78.5% of the cars on electric railways.

In brake equipment, 95.4% of the cars had hand brakes, 11.8% air brakes, and 7.7% had electric brakes, track brakes and other mechanical brakes. More than half the cars were heated, and of these 63.1% had electric apparatus, and 36.9% had stoves, hot water, etc. Of the total number of cars, 93.4% were lighted; 55,703 by electricity and 6,666 by oil, gas, etc.

There were 461,109 ft. of bridges, 65% were wooden bridges and trestles, 33.8% iron or steel bridges, and 1.2% masonry viaducts.

In regard to power plant, 764 companies using mechanical motive power had 805 power houses, besides which some companies rented power. Steam was used by 540 companies, with 2,336 engines of 1,298,133 HP. Of these engines, 1,588 were of 500 HP. or less, 431 of 500 to 1,000 HP., and 317 over 1,000 HP. The Union Traction Co., of Philadelphia, had 21 engines aggregating 37,800 HP., but the Interurban Street Ry., of New York, had 15 engines of 78,600 HP., and the Boston Elevated Ry. had 20 engines of 48,200 HP. There were also 159 water wheels, aggregating 49,153 HP.; of these, 129 were of 500 HP. or less, 12 between 500 and 1,000 HP., and 18 over 1,000 HP. Of the total water power, 69.6% was reported by 16 companies in California, Georgia, Maine, Minnesota and New York. The largest plant of this character was that of the Twin City Rapid Transit Co., of Minneapolis, with 12 wheels, ten of which were of 1,000 HP. each. The number and power of electric generators were as follows:

	Current—			
	Direct—		Alternating—	
	No.	HP.	No.	HP.
500 or under	2,324	422,924	329	61,935
500 to 1,000	328	218,934	54	36,418
1,000 and over	209	330,456	58	133,571
Total	2,861	972,314	441	231,924

For the United States the output of stations was 2,261,484,397 KW. hours for the year, or 6,249,910 per day; the HP. hours of current aggregated 3,018,320,717 for the year, or 8,338,190 per day.

PRACTICAL HINTS FOR BUILDERS OF OILED ROADS

In our issue of Aug. 27, the use of mineral oil in road improvement was discussed at length in an article by Mr. James W. Abbott, of the Office of Public Road Inquiries. As the better knowledge of the proper methods of oil roads becomes more general, it is probable that in other states besides California many hundred miles of earth roads will be advantageously treated with mineral oil having an asphaltic base. The proper handling of the oil should be understood by every experimenter, and to this end some advice given by Mr. Theodore F. White, of Chino, Cal., may prove valuable. Mr. White says:

It is important that travel be kept off the portion of the road being oiled until the process is finished. If the road cannot be closed altogether while the oiling is being done, then oil one side at a time, keeping the travel on the other side. When this side is finished, oiled, sanded and thoroughly mixed, leaving no wet oil on the surface to be picked up by vehicles, then turn the travel on this side and work the other.

It is easy to put too much oil on a road that has been oiled the previous season, and is for the most part smooth and firm. Too much oil will soften up the firm surface, the same as it will soften up an asphalt pavement, and part of the results of the previous oiling is temporarily lost.

Sanding serves a twofold purpose when put on a road that has been oiled before, and on a hard surface road. It

absorbs the surplus oil, making the road at once pleasant to travel over, and it adds to the wearing surface by covering it with a clear grit. Sharp sand such as masons select for their work, mixed with fine gravel, is the best for this purpose.

It is a good plan to have a pile of sand and gravel mixed with oil, to the saturation point, during the summer, to put into holes that may form in an oiled road during the succeeding winter; when it is difficult to mix the oil, and when there may be a long, wet spell that will render it impracticable to make repairs in the ordinary way.

The best time of year to oil roads is after the weather has become settled and it is dry and warm. We generally commence oiling in May, and continue the operation from that time on through the summer and fall, up to November. There are frequently, however, very foggy mornings in May, when oiling is done with difficulty. If the spring has been dry it may be well to oil certain roads that are liable to cut up under travel, in April. There is generally a warm settled spell during the latter part of this month.

The conditions are ideal for using oil on roads when the oil is hot, the weather dry and warm, and the roadbed warmed by the rays of the sun. I said this at the convention of California Municipalities in January, 1902, and I have seen no reason since for changing the conclusion.

But we cannot always realize the ideal; and the practical has frequently to take the precedence. In other words, we must do the best we can under the circumstances. Ever since I have been using oil on roads, I have used cold oil at times, when it was inconvenient to get it hot. Last summer I used a large quantity of cold oil on a road that was remote from any heating plant. This was a sandy road and the results were as good, probably, as if the oil had been heated. On loose sandy roads, the oil will soak in under almost any conditions of temperature. So, if I did not feel like incurring the expense of erecting a heating plant, I would still go on oiling roads; for if done during the warm summer months when the roadbed is warm and the oil is warm from the natural heat, good results can be obtained; especially if the oil is allowed to remain two or three hours under the rays of the midday sun before being disturbed with the mixer. Cold oil recommends itself, because of economy, for use on outlying country roads; especially if they are near some railroad siding, when a car can be side-tracked, a pit dug alongside (unless the car stands on an embankment) into which the oil wagon can be run, and filled by gravity. If there is no embankment, and it is impracticable to dig a pit, the oil can be discharged from the car by a simple rotary or other pump and a small gasoline or steam engine. In some sections small threshing engines can be hired for this purpose.

THE LEAMINGTON CUT-OFF OF THE OREGON SHORT LINE R. R IN WESTERN UTAH.

By W. P. Hardesty, C. E.*

The importance of direct alinement and easy grades and curves for a trunk-line route has become fully appreciated during the past few years, as witnessed by the entire rebuilding of long stretches of line on many of the trunk lines in the western part of the United States. One of the best examples showing the contrast between the old and the new is afforded by the work to be described.

The Utah Central R. R., from Ogden to Salt Lake City, was completed in 1869-70; the Utah Southern, from Salt Lake City to Juab, was begun in 1871 and built by stages till Juab was reached in 1879; and the Utah Southern Extension, from Juab to Milford and Frisco, was built in 1879-1880. These roads were built by separate companies, composed of the Mormon residents of Utah and Union Pacific R. R. interests, and, though separate in ownership, they were operated as one line and under one management. In 1881 the two latter were incorporated with the Utah Central. Like many of the other pioneer roads, the location of the line was dictated by considerations of economy in first cost, and though the road has answered well its purpose of taking care of local traffic, it fills none of the requirements of a line that has to handle the traffic of a transcontinental route at the present day.

In 1881-82 the Union Pacific R. R. Co. built a line from Lehi Junction, 29 miles south of Salt Lake City, running southwesterly, called the Salt Lake Western. This was intended to be a through line to Los Angeles, and was strongly favored by President S. H. H. Clark. This was opposed, however, and construction was abandoned after reaching a point called Tintic, just southwest of the Tintic Mining District. The road has since been known as the Tintic branch of the main Utah line.

Before this time, about 1876, another road, the Utah & Nevada (begun 1872), was completed by the Union Pacific, from Salt Lake City to a terminus near Stockton, a then flourishing mining camp. This road, which was narrow-gage, ran westerly to the south shore of Great Salt Lake, reaching Garfield Beach, 18 miles out, and at two miles further on it left the lake and ran southerly through the Tooele Valley to the station called Terminus, a distance of 37 miles. This road was also projected as a through line to southern California. All three of these lines were long controlled by the Union Pacific R. R., and with the segregation of the Oregon Short Line R. R. lines in 1897 they became parts of the latter system.

The extension of the Utah Central line, from Milford (221 miles from Salt Lake City) to the coast in southern California, has long been contemplated, and in 1889-90 over 140 miles of grade were constructed, leading from Milford on to Pioche, Nevada. During the past two or three years renewed attention has been drawn to the desirability of a line from Salt Lake City to southern California, and the accounts of the rivalry between the San Pedro, Los Angeles & Salt Lake and the Oregon Short Line railways for possession of rights of way through Nevada are still fresh in the public mind.

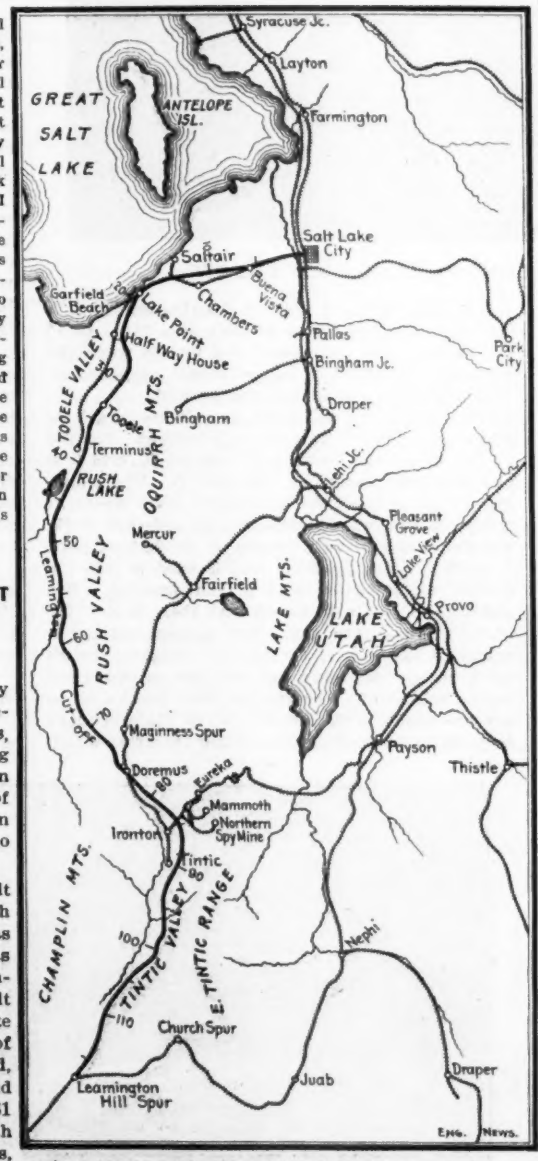


Fig. 1. Map of Railway Lines Running South from Salt Lake City.

A part of the latter company's plans for the through line was a radical change of a large part of its line from Salt Lake City to Milford. The old operated line from Salt Lake City to Leamington Hill, a point on a high mesa in Millard County, 133 miles distant, was not suitable for a through line, on account of excessive grades and distance. It was decided to connect these points by a totally different route.

The new line, called the Leamington cut-off (Fig. 1), has been constructed during the past year. It runs westerly from Salt Lake City for 20 miles, rounding the north end of the Oquirrh range of mountains where they break off toward the south shore of Great Salt Lake. Then, at Lake Point, the new line turns southerly, running through the Tooele valley, then through the Rush valley (both on the west side of the Oquirrh range), and finally through the Tintic valley, west of the Tintic range of mountains. The distance is 117 miles, as against 133 miles by the old line. For 38 miles the road runs very close to the old Utah & Nevada road (the track of which has been torn up), and for 7 or 8 miles it lies near the Tintic branch of the main line, but outside of this it runs through an entirely new country.

The guiding principle in location and construction was to furnish a roadbed in every way suited to form a part of a transcontinental route, and the standards and limits employed in the rebuilding of the Union Pacific Ry. in Wyoming have been used throughout. The maximum grade is .8% (42 ft. per mile), compensated on curves up to 3° at the rate of .03% per degree; for 3° 30′ curves and sharper, at .04% per degree. The maximum curvature is 4°. All curves of 2° and over are spiraled. The spiral used is an adaptation of Searle's, using a constant chord length of 30 ft. For 2° curves there are 7 chords; for 3°, 11 chords; and for 4°, 15 chords. This spiral is unusually long, the length for 4° curves being 450 ft. The required length of tangent between ends of spirals where curves turn in the same direction is 500 ft.; for reversed direction it is 600 ft. Breaks in grade are made with vertical curves, the rule being that the rate of change per 100 ft. shall not be over 0.1% on summits, and 0.05% on sags. The roadbed in embankments is 18 ft. wide, and cuts are excavated to 24 ft. width. In the latter case the roadbed proper is made 16 ft. wide, leaving 4 ft. on each side for excavation of a drain ditch, 1 ft. deep. Slopes in all earth cuts are 1½ to 1, and for firmer material they vary to suit the case.

All covered openings for drainage are either cast-iron pipe or concrete arch culverts, and for a few small irrigation ditches near grade wooden box culverts are used. The provision for drainage is most complete, although the line runs through an arid region for most of its distance. The only perennial stream crossed is the Jordan River, in Salt Lake City.

The preliminary surveys and nearly all of the location were made by Mr. B. F. House. For construction, the line was divided into two districts. The first district, embracing 65 miles of line out from Salt Lake City, was in charge of Mr. E. G. Taber, and the second one, taking in the 52 miles of line at the south end, was in charge of Mr. House. The entire work was in general charge of Mr. W. M. Ashton, Resident Engineer for the Oregon Short Line R. R. Co., which office carries with it all the duties of that of a chief engineer. The Leamington cut-off location and construction were under the general supervision of Mr. W. P. Watson until his resignation on Dec. 1, 1902, after which his former work was conducted directly by Mr. Ashton's office. The line was divided into divisions from 8 to 16 miles in length, each in immediate charge of a division engineer. There were six divisions on each district. The contract for building was let to the Utah Construction Co., of Ogden, Utah.

LOCATION.

Beginning at the Salt Lake City yards (Fig. 1), the line follows that of the old Utah & Nevada for 3½ miles, the roadbed being widened and improved, to Buena Vista Station, where material yards were located. It here leaves the old line and heads directly for a point near Garfield Beach, formerly reached by a detour to the south. The new line here has a tangent 13 miles long. The

*Montpelier, Idaho.

grade to Garfield Beach is practically level. Shortly beyond this point an ascending grade of the maximum of 0.8% begins, and it continues to the Stockton cut, a distance of 20 miles. In the first two miles of this occurs about the only really solid rock on the line.

In the Tooele valley the ascending grade takes the line in places as much as two miles from the old road. The latter keeps on the flatter ground nearer the bottom, with an undulating grade, some of it adverse, so that notwithstanding that a 1% rate is kept up for most of the last 13 miles of it, at Terminus Station it is below the new grade. The new line, which keeps on the eastern slope of the wide Tooele valley, has more distance, more curvature and more grading than would be necessary on one following the lower level of the old one, but the location is necessary to gain the required elevation at the Stockton bar.

Thus, notwithstanding the features that could have been taken advantage of by a narrow-gage line, or one with the limits formerly permissible for a standard-gage line, the new line was compelled to use a continuous maximum grade for 20 miles, and then to go through the bar with a cut of 100 ft. in depth, containing 780,000 cu. yds. of material. Former surveys have shown that a 1% line will reach the top of the bar in 18 miles, starting at the north end of the Tooele valley.

FIG. 2. EXCAVATING STOCKTON BAR CUT, LEAMINGTON CUT-OFF.

STOCKTON BAR CUT.

The Stockton bar is a remarkable bench or dyke, presumably all composed of sand, gravel and other material deposited by the action of the waters in Lake Bonneville, the ancient body of water which once occupied the basin of Great Salt Lake. The bar connects the Oquirrh range with the Stansbury range, to the west, and forms a divide between Tooele valley and Rush valley, to the south. These valleys once formed only a single valley and the bar occurs at its most constricted part, about 1½ miles in width.

A profile of the bar, from east to west, shows it to be nearly level. The top corresponds with the high-water level of Lake Bonneville, and is a little over 1,000 ft. higher than the present surface of the lake. Being deposited across the wide, trough-shaped basins of the two valleys which it separates, the result is that each valley abruptly terminates. From these basins the natural slopes of the sides of the bar (at angles of 30° to 35°) lead directly to the top, over 300 ft. higher. At the highest part of this natural embankment, near its west end, the width is much less than towards the east end, forming a narrow neck of land.

When the Utah & Nevada R. R. ceased building at Terminus Station, on the north side of the bar, the survey for a continuation of the road through the bar called for a line following closely the hillside till the narrowest part of the bar was reached, and then reversing to the left and passing through this on a tangent with a tunnel not over 800 ft. long, with shallow approach cuts. At the south end the line curved to the eastward, running along a lower level of the bench and passing on to the slopes of the Rush valley. Ten degree curves were required at each end of the tunnel.

A line enabled to pass through the bar at the low level of this survey would have the advantages of easier grades, shortened distance and easier ground to build through for a distance of nearly 25 miles. But the curve limits of the new line would not allow of the detour and the turn required, and the deep V-shaped basins adjacent to the neck of the bar afforded no supporting ground for approaching it head-on or directly.

A tunnel, of about 2,000 ft. length, was at first contemplated, but test pits, sunk to a depth of 75 ft., showed that only sand and gravel would be encountered, which of course meant very expensive work for supporting the ground.

The cut (Fig. 2), is 3,500 ft. in extreme length, of which over 3,000 ft. is a through cutting. For 700 ft. the cut on the center line runs 95 ft., and it is nowhere less than 85 ft. for 1,150 ft. The transverse slope of the ground is nearly level except at the north end, where there is some side-hill work. The cut is 320 ft. wide on top at the deepest part. A vertical curve 2,300 ft. long is used to join the grades on opposite sides of the summit. The north end is on a 4° curve, and there is a 1° 20′ curve at the south end. The deepest cutting is near the north end, through the highest bench level, which continues out to the narrow neck before spoken of. The surface then breaks off to another bench to the south, the cut being reduced from 95 ft. to 48 ft. inside of 250 ft., after which it gradually tapers out. The bottom was made only 20 ft. wide, the intention being to widen it by additional excavation for ballast material. Side slopes are 1½ to 1.

The cut was excavated by the Flick & Johnson Construction Co., who took the subcontract for this work alone. The excavation was made with steam shovels, loading on to dump cars that were hauled by "dinkey" engines out to dumping grounds and wasted. A 65-ton Bucyrus shovel was used at either end. These shovels, which have dippers of about 2½ cu. yds. capacity, did excellent work. With a 14-ft. reach, the limit of width cut by one is 28 ft. They averaged about 25 ft. width of cutting, with a depth of usually 12 to 15 ft. at each passage of the shovel. Much time was lost in shovel work on account of moving the dump car tracks.

Apparently, a shortage in the amount of track material caused the work to be done at a disadvantage, both on account of more frequent changes and the failure to reach more suitable dumping grounds. The material was loaded into the cars, which were made up into trains of 9 to 14 cars, usually of about 12. Most of the cars were of the 3-yd. size, some of 4 yds. One was loaded with two shovelfulls. Records kept throughout the work (keeping tab on the number of carloads and measuring the material excavated) showed that the average carload varied from 3¼ cu. yds. in the early summer months to 2½ cu. yds. in the late winter months. Two shifts of ten hours each were worked. The average record for the two shovels in 24 hours was about 3,700 cu. yds., with a maximum of 7,000.

On an average about 100 to 150 men were worked during the day and 50 to 60 at night. During the day all needed track changes were completed, to avoid the disadvantage of such work in darkness, and other extra work was attended to, so that a good run with the shovels could be made during the night.

Over the entire bar, and within 2 or 3 ft. of the surface, a layer of cemented gravel was found, running from 1 to 5 ft. in thickness. This had to be shot, but all the rest of the cut could be taken out without the use of powder, though it was often used to make easier work for the shovels. Over 2,000 cu. yds. was classified as solid rock and about 40,000 as loose rock. Much the greater part of the material was wasted from the south end of the cut.

Two engines were used on each train of dump cars, delivering the train to another engine at the dumping grounds. This engine handled the train in unloading, while the two engines returned to the shovel with a train of empties.

A 45-ton Vulcan shovel was also used to some extent on the work.

For a water supply to the shovels and engines, and also the electric light plant needed for night-work, the contractors were obliged to build a pipe line three miles long. Water was pumped from some springs near Rush Lake, being forced through a 3-in. main to a wooden tank on top of the bar.

FIG. 3. A 50-FT. CUTTING ON MILE 70; WEAVER & THOMPSON, SUB-CONTRACTORS.

Gravel pits will be opened in the Stockton bar cut, using the material for ballasting the track. This material ranges from sand to cobble stones as large as a quart cup, which latter will have to be separated in spreading the ballast.

Just how deep it is to solid rock at the Stockton bar is not known. It seems probable that a comb or crest must have projected above the general surface originally, in order to start the accumulation of sand and gravel at the site.

Just north of the bar, at Terminus Station, a 7,000-ft. drain tunnel is being built, to drain the famous Honorine and other mines on the slope of the mountains to the eastward. This tunnel, which will serve both for drainage and in place of shafts for operation, starts well toward the bottom of the basin and runs southeasterly into the mountain side, crossing the railroad at about 140 ft. below its grade. For ½ mile in from the mouth no solid rock at all is encountered, the material varying from a mixture of sand and clay to heavy cobble stones. Hard material was run into only after the tunnel was bored to a point even with the slope of the mountains, at a depth of 250 to 300 ft.

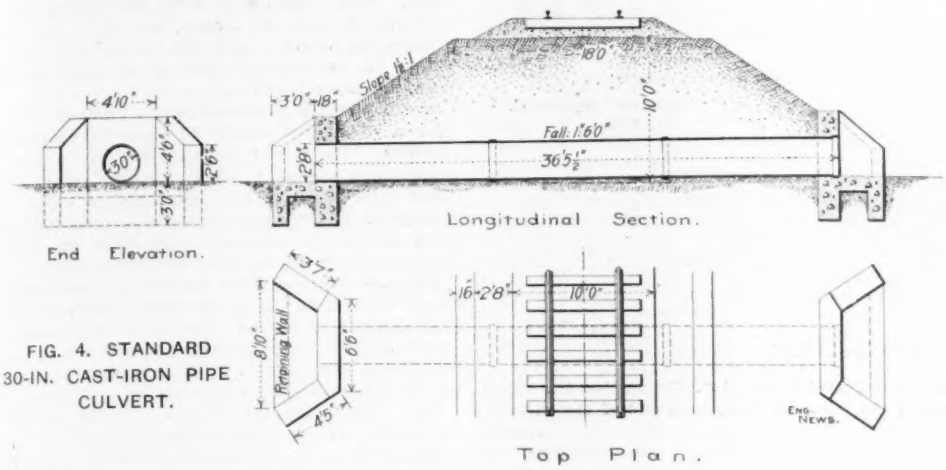


FIG. 4. STANDARD 30-IN. CAST-IRON PIPE CULVERT.

LOCATION FROM STOCKTON SOUTHWARD.

Going south from the Stockton bar the grade descends into the Rush valley, a rate of 0.65% (34 ft. per mile), serving to reach the bottom in about three miles distance. The line runs by the town of Stockton, just beyond the bar. Rush valley is an arid basin draining into Rush lake at its north end, which has no outlet.

Then follow between 11 and 12 miles of light grades, except for one stretch of ¾ mile of the maximum ascending, with comparatively light work. There is also one tangent of 10 miles length through this valley.

In mile 55 an ascending grade of 0.7% to the south begins, the line keeping on the west slope of the basin. This is increased at the end of two miles to the maximum of 0.8%, which is unbroken, save for the compensation on curves, for the distance of nearly 22 miles to Boulder summit, which separates Rush valley from Tintic valley on the south. On miles 58 and 59 a long swale has to be crossed, which is the principal feature in controlling the elevation of the grade line from here to the summit, 20 miles distant. The grade is adjusted to make a fill averaging from 15 to 18 ft. for a distance of 8,800 ft. across the swale. This fill has a maximum height of 22 ft., and it contains 160,000 cu. yds.

On mile 70 is a cut (Fig. 3) with a maximum of 50 ft. on the center line, which, though only 550 ft. long, contains nearly 57,000 cu. yds. On mile 71 is another cut containing 45,000 cu. yds., and on mile 76 is a cut 1,050 ft. long, and containing 105,500 cu. yds. This has a maximum depth of 53 ft. on the center.

The Boulder summit, at the end of mile 79, is crossed with a cut 1,900 ft. in length and containing 103,000 cu. yds. The maximum depth here is 52 ft.

From Boulder summit going south an almost continuous descending grade of the maximum of 0.8% is required for a distance of 26 miles to reach the bottom of the Tintic valley. The line lies on the east side of the valley. A grade rate of 1% would reach the bottom in a much shorter distance, and by adopting a maximum of about 1½% for the first few miles the bottom of the valley could then be followed with a grade of not over 1% at the start and gradually reducing to almost level.

There is only comparatively light work beyond mile 102. In mile 106 the end of the supported grade of 0.8% is reached. Back of this point, on mile 101, there is a reduction to a grade of 0.16% extending over ½ mile, to avoid too heavy a cutting in crossing a ridge. Beyond mile 106 the grade is undulating, with short lengths of light adverse grade. The drainage from the valley soon disappears in sinks beyond this point, and the country opens out onto the broad Sevier River Desert. There is one tangent of 4 miles in length shortly before joining the old line at a siding on Leamington Hill.

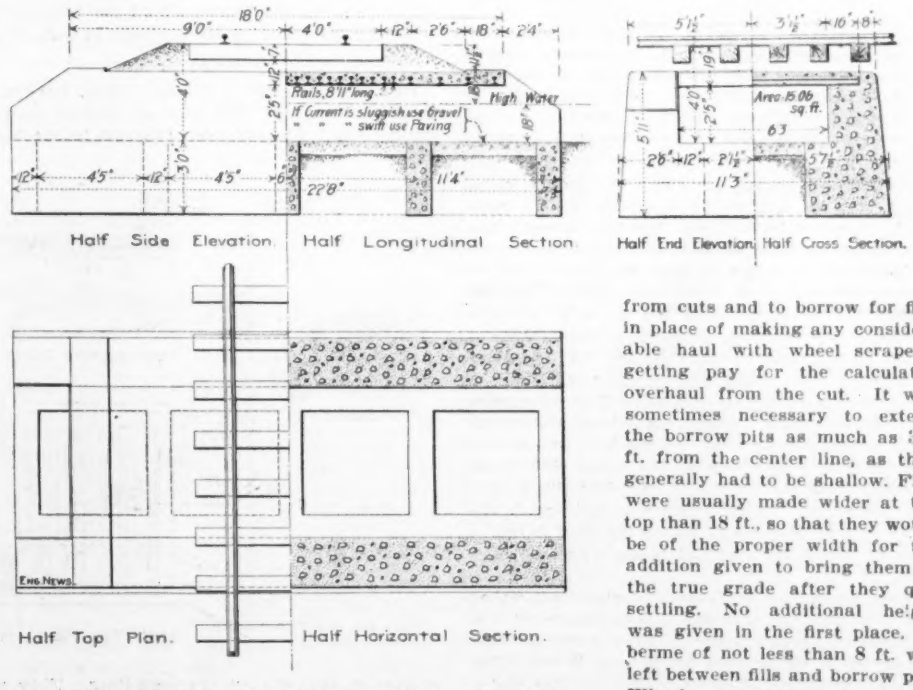


FIG. 5. STANDARD RAIL TOP CULVERT, 6 FT. 3 IN. SPAN.

There are no curves shorter than 3° on the south side of Boulder summit, ranging from that down to as light as 0° 30'. On the second district north of the summit there are but four curves as sharp as 4°, and on the first district there are but two.

The Leamington cut-off crosses the spur from Ironton in mile 85, at about two miles above Ironton. Trains were formerly backed up this spur from Ironton (the terminus of the main branch) to the towns of the Tintic Mining District, a distance of five miles. From the station of Tintic Junction, near here, a 3-track spur connects with the older system. The mining camp is reached by stub trains from this point. A climb of over 500 ft. is required to reach the station at Eureka.

The elevation of the road above the true sea level varies from a little over 4,200 ft. near Great Salt Lake to nearly 6,100 on Boulder summit. It is over 5,100 in the Stockton cut and about 5,000 at the north end of Rush Valley. At Salt Lake City it is about 4,250, and 4,800 on Leamington Hill.

The continuous supported grades used to ascend the summit on this line are unusually long. The grade line being rigidly fixed beforehand, and the limits of curves and connecting spirals and tangents calling for an alinement that can be made to follow only the general features of the country, the matter of a location becomes one involving much skill and judgment as well as labor. By following along near the bottom of the three valleys traversed, on drainage grade lines, the material to be moved would have been nearly all earth. The amount of grading would have been vastly less and the alinement much more direct, but all of this would have been impossible without using grades ranging from 1 to 2%. As built, the maximum grade each way is 0.8%, except where running from South Temple St. into the yards at Salt Lake City, where a 1.34% grade is necessary by reason of the street grades being fixed.

GRADING.

A considerable portion of the grading was done, and all the structures built, by the Utah Construction Co. with its own force, and the balance let in subcontracts covering from one to nine miles. The different methods of handling dirt, by scrapers, graders and steam shovels, were all used on construction. The free haul was 500 ft., and limit of haul 2,000 ft. The wheel scrapers were not used for actual hauls much exceeding 500 ft. Graders, loading directly onto dump wagons, were used by several of the sub-contractors for long hauls, some of which amounted to nearly 2,000 ft. The contractors often preferred to waste from cuts and to borrow for fills in place of making any considerable haul with wheel scrapers, getting pay for the calculated overhaul from the cut. It was sometimes necessary to extend the borrow pits as much as 300 ft. from the center line, as they generally had to be shallow. Fills were usually made wider at the top than 18 ft., so that they would be of the proper width for the addition given to bring them to the true grade after they quit settling. No additional height was given in the first place. A berme of not less than 8 ft. was left between fills and borrow pits. Wheel scrapers were also used to dump through traps into dump wagons, and in one case tongue scrapers were used to dump through a trap into 3-yd. dump cars, which were hauled by horses. Steam shovels were used on most of the heavier cuts. No shovels over the 45-ton size were used except on the Stockton bar cut, and the light shovels as a rule did not seem to be as satisfactory as the large ones. Some of the light ones, under favorable conditions, would move as much as 800 to 1,000 cu. yds. per day. The dippers in these were of 1¼ to 1½ cu. yds. capacity. Some of the cuts taken out by steam shovels were made

wider than required, in order to obtain needed material for adjacent fills, this method of borrowing being peculiarly adapted to steam shovels.

DRAINAGE.

The entire line is well provided with drainage ways. Crossing the wet alkaline flats west of Salt Lake City, a continuous drain ditch was excavated on each side of the roadbed, on the right-of-way. At long intervals an outlet ditch is run

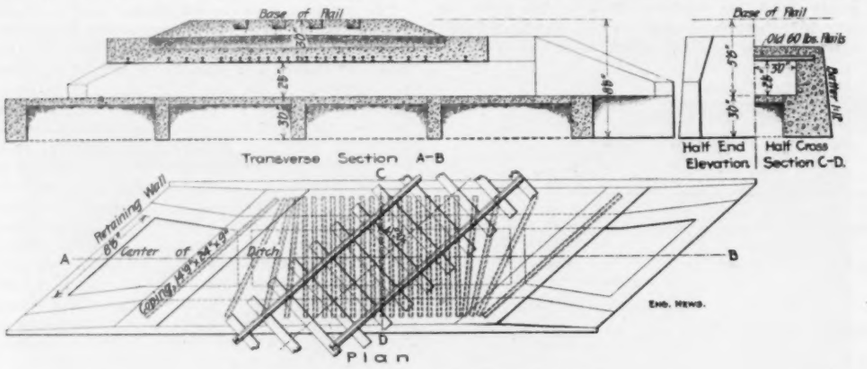


FIG. 6. 6-FT. RAIL TOP SKEW CULVERT.

from these to the northward, to discharge onto lower ground. Irrigation ditch crossings are made usually by use of a box culvert, but in some cases by a concrete culvert with a top made of old rails embedded in concrete. A form of culvert permitting a very near approach to grade is usually necessary for irrigation ditches. As the rule is to keep the grade above the natural surface wherever practicable, in open flat country the line is in fill averaging 3 to 4 ft. Through the Salt Lake Valley it ranges from 1½ to 7 or 8 ft.

Where the line lies on the slope from the mountains, at Lake Point and beyond, the rush of waters that takes place from the gulches and canons after a cloud-burst is provided for by building a short diversion ditch at the mouth of such canons and carrying the water over into a drainage basin. This is because of the fact the floods have brought down boulders, etc., and piled them into long moraines reaching out towards the valley, the water channels remaining on the moraines, and where the roadbed cuts through the latter it is subject to floods pouring down into the cut unless the water is diverted Such channels have been treated, where they issue from the base of the mountains, at distances of ½ mile or even ¾ mile from the line.

Drainage water is often conveyed in ditches across the drainage lines for ⅛ mile or more alongside the roadbed, in order to concentrate it at one opening and so make the one take the place of several. The drain ditches are usually out a safe distance from the roadbed. This sometimes required deep cuts through the ridges, and where these would be too deep the cut for the roadbed is made 4 to 6 ft. wider on the upper side, so as to make room for a ditch of sufficient size alongside the track. Often where the drainage is divided on a ridge through which the road is cut, a dyke of the waste material is made instead of a ditch.

The openings for drainage are nearly all either cast-iron pipe or concrete-arch culverts, of the Oregon Short Line standards, Figs. 4 and 5. The former are of three sizes, 24, 36 and 48 ins. The culvert is made of full sections of 12-ft. pipe and a part length of 3 ft. or some multiple of 3 ft., as required. The lengths are put together without caulking or cement. A concrete cross-wall, with a good footing, is built at each end of the pipe. The pipe between these rests on the ground, which is well tamped. A slight camber is given to allow for settlement due to the weight of the fill on top.

On the first district are 36 24-in., 12 36-in. and three 48-in. pipe culverts. On the second district there are 29 of the 24-in., 19 of the 36-in., and 16 of the 48-in.

Concrete culverts (Figs. 5 to 7) are used for the larger openings. They are of either 6-ft. or 8-ft. span. On the first district there is one of each size. On the second district there are nine of the first size and two of the latter. The 8-ft. arch has side walls 5½ ft. high, making a clear height of 9½ ft. Under each wall is a footing course, 6 ft. wide and 3½ ft. deep. The walls batter from 4 ft. width at the bottom to 3½ ft. at the springing line, and the arch tapers to 14 ins. thickness at the crown. Heavy spandrel walls and wing walls, resting on footing courses, are at each end. The bottom is paved with stones 12 ins. deep, on a sand and gravel foundation. Connecting the outer end of the wing walls, at each end of the culvert, is another course of the same depth as a footing, which prevents underscouring the pavement. In long culverts, at intervals of about 50 ft., the footing courses are also connected by a wall across the bottom, which also helps hold the paving in place. The slope of the fill catches just behind the parapet wall at each end.

Utah Portland cement, sand and broken stone in proportions of 1, 3 and 6 are used for the concrete.

Outside of the pile-trestle bridge across the Jordan River there are but four of such bridges on the entire line. The standard pile bridges have bents spaced 15 ft., with five piles in each bent.

TRACK.

The ties used are 7 × 8-in. × 8-ft. Oregon fir, 3,000 to the mile. The rails at present used are 60-lb. rails that have been released in the laying of heavier rails on the operated lines. They will doubtless be replaced by much heavier steel when the line is completed to southern California. Tie-plates are used on curves, and 36-in. 4-hole angle bars are used. So far only the line from Buena Vista across the wet clay ground to near Garfield has been ballasted. The excellent ballast here used, which came from Point of Mountain on the old line, is placed 7 ins. under and between the ties, and extends 1 ft. beyond their ends. The remaining ballast will be obtained from the Stockton bar cut.

The track on curves is elevated for a 40-mile speed for the present, though the system of curves and spirals was designed for a 50-mile speed. Tracklaying is done by the railroad company's own force, with a tracklaying machine.

RIGHT-OF-WAY.

This is 200 ft. wide over the public lands, where it is obtained by U. S. grant. Where over private ground it is usually 100 ft., but sometimes more where there are high cuts or fills, or where ground for borrow is needed. The right-of-way has been fenced through all of the settled localities.

STATIONS.

At every way station a passing track 3,000 ft. long is put in, spaced 15 ft. centers from the main track. Where there is no depot the loading track switches off from the former, but where there is a depot the loading and house tracks are usually placed on the opposite side of the main track, with the depot between.

Much difficulty is experienced over most of the line in securing a supply of water for watering stations. The water usually has to be piped (sometimes pumped) from springs, which are often some distance from the line. A sufficient supply of water was also quite a consideration with the contractors, who sometimes dug wells and sometimes hauled from springs.

The cut-off passed from the hands of the Oregon Short Line R. R. Co. at the time of the purchase last summer of all the property of the company south of Salt Lake City by the San Pedro, Los Angeles & Salt Lake R. R. Co., and will form part of the latter company's through line to California.

The Leamington cut-off is a splendid example of recent railway engineering practice, and reflects credit on those connected with its construction. The completion of the contemplated through line to southern California will provide a new route for transcontinental traffic, over a road strictly in keeping with advanced railway standards, and one far better adapted for economical handling of heavy traffic than any of the older lines as first constructed.

REPORT OF THE MERCHANTS' ASSOCIATION ON IMPROVING THE SURFACE CAR SERVICE OF NEW YORK CITY.

In December, 1902, the Merchants' Association of New York city, impelled by frequent and growing complaints of overcrowding and the general inadequacy of the surface car lines of the city to carry their passengers comfortably and expeditiously, undertook the task of searching out the causes of these troubles, and of devising remedies for them. Two committees were appointed, one on legislation and one on engineering and sanitation, to carry on the actual work. The full report of these committees has just been published by the Association in an interesting volume of 216 pages, the bulk of which is taken up by the report of the Committee on Engineering and Sanitation. This committee is composed of the following members: Mr. Samuel Whinery, H. W. Brinkerhoff, Foster Crowell, C. H. Myers and George A. Soper, Ms. Am. Soc. C. E., and F. F. Woodward, Secretary. This committee worked without compensation, and its report is a most

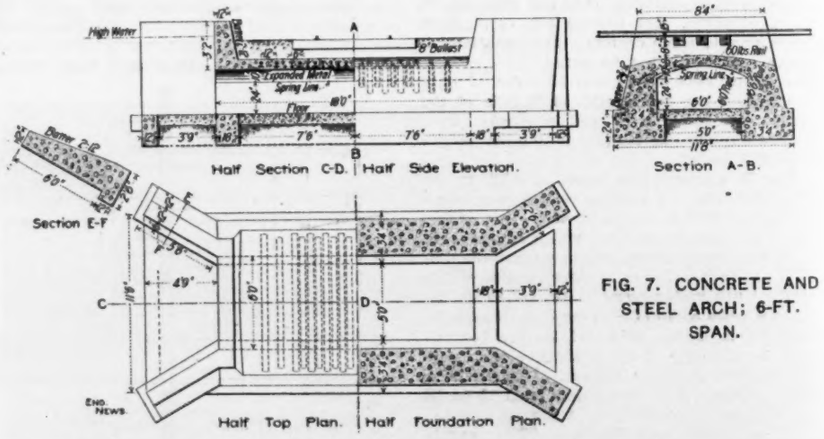


FIG. 7. CONCRETE AND STEEL ARCH; 6-FT. SPAN.

comprehensive document on the subjects with which it is concerned. Such of the features of the report as are of most general interest are abstracted in the following paragraphs:

SPEED OF CARS.

The average speed at which a car can be safely operated upon a double-track road is limited by certain physical conditions which may be briefly discussed. The operation of stopping and starting consumes a certain amount of time which varies with the speed of the car, the power of effectiveness of the brakes and the ability of the motorman. The distance within which a car can be stopped varies nearly as the square of the speed. In other words, it requires about four times the distance to stop a car moving at ten miles per hour as to stop one moving at five miles per hour, and the same law holds good in attaining a given speed. On the other hand, the time consumed in stopping or starting varies directly as the speed. The time lost in stopping and starting the car is an important element in determining the capacity of any line, and the percentage of time thus lost becomes greater as the speed is increased. Furthermore, if the stops are near together the car may not be able to attain its highest allowable speed before it becomes necessary to shut off the power and apply the brakes in order to stop at the point desired, and the speed attainable may be limited by that cause.

To maintain a given average speed, including stops, it is necessary, of course, that a car shall run between stops at a higher speed than the average. Over crowded streets a speed of about 12 miles per hour cannot be exceeded with safety. At this rate a car moves about 18 ft. in one second, and from this speed a loaded car of the kind used on Broadway cannot probably be brought to an emergency stop with the hand brakes now in use in a distance much less than 60 ft. In ordinary service the average distance covered after application of the brakes before the car comes to a standstill from a speed of 12 miles per hour is probably about 80 ft. and the time occupied is probably nine seconds. The time occupied in regaining a speed of 12 miles per hour from the starting of the car is probably about seven seconds. Making the necessary allowance for stopping and for reduced speed at street crossings where the car does not stop, it may be computed that the average speed of a Broadway car, restricted to a maximum speed of 12 miles per hour, could not much exceed eight miles per hour, or two-thirds of the maximum speed, even if no obstructions to free movement existed.

With a proper regulation of vehicular travel upon the street and the removal, so far as practicable, of other causes of delay, the committee believes that a near approach to an average speed of eight miles per hour could be maintained at all times throughout the day.

TABLE I.—Showing Number of Cars Passing a Given Point in One Hour at Different Speeds.

Speed in Miles per Hour		Feet Traveled in One Second at Max. Speed (c)	Time and Distance Required to Stop after Application of Brake		Distance from Front to Front of Cars ($a+b+c+d$)	Number of Cars per Hour and Headway	
Max.	Av.		Time Secs.	Dist. Feet (d)	Feet	No. per Hour	H'dway Secs.
6	4	8.8	3.43	15.1	75	281	12⅘
8	5⅓	11.7	4.57	26.7	89	316	11⅔
10	6⅔	14.7	5.71	42.0	108	325	11 1/16
12	8	17.6	6.86	60.4	129	327	11
15	10	22.0	8.57	94.3	167	316	11⅔
18	12	26.4	10.28	135.7	213	297	12

Average speed = ⅔ of a maximum speed.
Brake retardation = 1¾ miles per hour, per second.
Length of car = 36 ft., over all = (a).
Minimum clearance allowable at stop = 15 ft. = (b).
Time allowance for delay in applying brake = 1 second.

To insure safety in operation a certain distance must be maintained between cars operated in the same direction upon the same track. This distance depends mainly upon the maximum speed of the car and varies about as the square of that speed. In other words, cars operated at 12 miles per hour must be kept about four times as far apart as cars operated at six miles per hour. This fact that the safe distance between cars increases so much more rapidly than the speed of the cars explains why increasing the speed above a certain limit may decrease rather than increase the number of cars that can be moved past a given point in a given time. Knowing the maximum speed at which the cars are moved, the rate at which the speed can be reduced by the brake, the length of the car and the proper allowance for delay in applying the brake and for a safe margin of space at the stopping point, it is possible to compute the distance that must be maintained between cars when running at full speed. Table I. has been computed on assumptions applicable to the crowded streets of New York, and it demonstrates the statements made above.

It will be noted that, under the conditions assumed, the greatest number of cars per hour can be moved when the maximum speed is 10 or 12 miles per hour and the average speed is about seven or eight miles per hour, and that with speeds higher or lower than these the number of cars that can be operated grows less. It is of interest to note further that the number of cars that can be operated at an average speed of 12 miles per hour is but slightly greater than the number that can be operated at an average speed of four miles per hour.

The table shows that a maximum speed of 12 miles per hour, equivalent to an average speed of about eight miles per hour, the space between cars cannot safely be less, theoretically, than 129 ft. The average speed of the car being eight miles per hour the number of cars 36 ft. long, spaced 129 ft. apart that will pass a given point in one hour is 327. In practice, under usual conditions of service on congested streets, the number of cars moved per hour past any given point would be materially less. Even if the tracks were kept reasonably clear of slow-moving vehicles and other preventable obstructions, the interference caused by the vehicles that cross the tracks at cross streets would delay the car movement very seriously, and as we shall next point out, the time lost at stops will still further reduce the number of cars that can be operated.

EFFECTS OF STOPS.

The theoretical time consumed by the operation of stopping and starting the car may be closely computed when the speed, the efficiency of the brakes and the power of the motor are known. This time increases directly as the speed.

In order that the cars may not interefere with each other at these stops a certain spacing between the cars, both in time and distance, is necessary. When a car stops, the following car approaches it rapidly, and, if the stop exceeds a certain time, may approach too closely for safety, unless its speed be reduced, thus adding to the time lost by it. In operation the cars should be kept under such control that they may be prevented from approaching nearer to each other at stopping places than, say, 15 ft. To insure this condition the time interval between cars of usual length operated at ordinary speed is approximately nine seconds, plus the number of seconds the cars actually remain at rest. Thus, to allow a stop of five second the time interval between cars must be 14 seconds, and for every second longer that the car remains standing the time interval between the cars must be increased one second. It is probable that in practical operation, at an average speed of eight miles per hour, requiring a maximum speed of 12 miles per hour, an average time interval of 16 seconds between cars on crowded streets is as small as safety would permit. If this conclusion is correct, it appears that the time consumed by stops is a limiting element in the car capacity of a line, regardless of other considerations.

With a time interval of 16 seconds the number of cars that may be moved past a given point per hour is 225. The committee does not believe that on congested streets like Broadway a service of more than 220 cars per hour passing a given point in one direction could be reasonably expected under the most favorable circumstances likely to occur, but we believe that this number per hour is a reasonable estimate of what should be done.

If we assume that a movement of 220 cars per hour is practicable under favorable conditions, the average time interval between them would be about 16½ seconds, and this would admit of a stop for passengers of from seven to eight seconds. In practice this length of stop is rarely exceeded except at some of the more important transfer points. If stops longer than this occur the movement of the cars following will be delayed.

Since, as we have shown, the length of stops is the controlling factor in determining the number of cars that can be operated over a line, it is obviously important that every possible means should be employed to keep the time consumed by stops at the lowest limit. As one expedient for limiting stops to the shortest time and for other reasons herein stated, the committee recommends that on congested lines upon each closed car, having a length of car body exceeding 28 ft., two men, in addition to the motorman, should be employed. We believe that such an arrangement will not only tend to reduce the length of stops, but will also conduce to the safety and convenience of passengers.

From the point of view of the public, it might be confidently expected that, if one man were stationed constantly upon the rear platform of the car, whose duties were to give starting signals and have control of the letting off and taking on of passengers at the end of the car, no unnecessary time would be lost at stops, and at the same time no start would be made until passengers were safely on or off the steps. His presence on the rear platform would expedite the loading and unloading. The other employee would always remain inside the car collecting fares and issuing transfers and beyond giving signals to stop, as passengers may indicate their wish to get off, would have no control over the movement of the car. It might be sufficient if the extra man were used during the rush hours only.

If every second cross street only were designated as a stopping place, the reduction in the number of stops would enable the cars to make better time, though the necessity for keeping the car under control at the intermediate crossings would, to some extent, reduce the advantage gained by the fewer stops. In the opinion of your committee the adoption of a rule to stop cars for passengers at every second street only might be expected to aid materially in bringing the average speed of cars up to eight miles an hour, providing the tracks were kept reasonably free from obstruction. If the stopping places were properly designated and plainly marked they would soon become familiar to those using the cars, and the inconvenience of sometimes having to walk an addition block would be so slight that it ought not to be objected to.

CAPACITY OR SIZE OF CARS.

The second element, affecting the carrying capacity of a surface line, is the size of individual cars. At the present time the best size for cars for use in city service is largely a matter of opinion. In practical use there is doubtless a certain size of car, which, all things considered, is suited to give the most satisfactory results upon the streets of a large city. If the cars are too small, not only is the capacity for service to the public diminished, but the earning capacity to the operating company is also reduced without any corresponding benefits to either party. If they are excessively large the aggregate capacity of the line may be decreased rather than increased, because, as we have seen, the length of stop made for taking on and letting off passengers is practically the controlling element in determining the number of cars that can be operated, and it is a well-demonstrated fact that more time is consumed in letting off passengers from very large cars, particularly when crowded with passengers, than from smaller cars.

While the largest size of closed cars now in use on Broadway and other lines, which have a body about 28 ft. long and a seating capacity of about 36 passengers, may be most economical for operation on the most crowded streets, the committee is inclined to believe that still larger cars, seating about 52 passengers each, would be practicable and would increase the present carrying capacity of the lines nearly 75%. Cars even larger than those we here suggest are already in common use on suburban lines, and the committee learns that the general tendency at the present time is toward larger cars for urban use also. The objection that, in city service where stops are frequent, the difficulty of collecting fares in large cars is increased, would not apply, if, as we recommend, two men besides the motorman, were employed on each car.

Attention is called to the fact that in his recent "Report Upon the Engineering and Operating Features of the Chicago Transportation Problem," Mr. B. J. Arnold, a recognized authority upon the subject, recommends the exclusive use of cars having a seating capacity of 52 passengers upon the crowded lines of that city.

DOUBLE-DECK CARS.

The committee, while recognizing the many advantages which the double-deck car affords and feeling well satisfied that in many localities it would provide the solution of the most serious of the various problems affecting street passenger transportation, is yet compelled, but not without great reluctance, to withhold an unqualified recommendation for its introduction in Manhattan for the following reasons, which will be briefly stated: In the first place, we find that double-deck cars could not be used universally, or even generally, in Manhattan, because of insufficient headroom beneath the elevated railroad structures at a number of places. In the second place, it cannot be foretold whether the public would favor the double-deck car in Manhattan; that could only be ascertained by actual trial. Experience gained in other cities, where climatic conditions and the habits of the people are different from ours, cannot be taken as an absolute guide.

The objection made to cars of large capacity, that they cause delay by more frequent and longer stops, may be neutralized in the double-deck cars by requiring upper-deck passengers to be on the platform before the car is stopped for them. Where this regulation is enforced the double-deck cars make even shorter stops than the ordinary ones. The reversed stairway decently adopted and brought into almost universal use on the later English double-deck cars make it possible for passengers to ascend and descend the stairs with perfect safety, even while the car is in rapid motion. The one objection to the double-deck cars is the uncertainty of the most uncertain thing—popular favor for a new article—and for that reason we have hesitated to positively recommend their adoption, but the probable advantages, both to the public and to the companies, seems so great, especially in view of abundant and increasing foreign experience, that we would urge the great importance of putting a sufficient number of these cars in use to give the matter a fair trial.

CAR AND LINE CAPACITY REQUIRED.

In estimating the carrying capacity required to accommodate the business of any surface car line, the character, as well as the quantity of travel, must be considered. On lines where a large number of the passengers ride for short distances only it is difficult to determine the average number of passengers occupying the cars at any given time, or to compute therefrom the number of passengers that should be provided for on a given route. The number of fares registered during a trip of any car furnishes no reliable indication of the number of passengers occupying that car at any one time. Observations taken at a given point will usually show that while many cars may be overcrowded others following them closely may have a number of vacant seats, while at some point further on

these conditions may be reversed with reference to these particular cars, showing that, in order to avoid overcrowding, accommodation must be provided in excess of the actual number of passengers to be carried.

OPEN CARS.

In what has heretofore been said the committee has had reference chiefly to closed cars. The condition in regard to the open cars is somewhat different. It is popularly supposed that because of the opportunities for loading and unloading along the sides of these open cars these operations are conducted more expeditiously than is possible with closed cars. Our observations do not confirm this conclusion. The cross seats, holding five passengers each, and being placed as near together as practicable, make both the entering and leaving of passengers slow and difficult. This is true in an aggregated degree where standing passengers are admitted between the seats or upon the running board, and the time and difficulty of entering or leaving these cars is, usually, as great or even greater than on the closed cars.

OPERATING SURFACE CARS IN TRAINS.

The operation of surface cars in trains of two or more has been suggested, and the committee has given the matter consideration. Trains of two cars have been operated in a number of cities, but in most cases the rear car has been a "trailer"—this is, it has been drawn by the forward car and has not been equipped with power of its own. The results have not been satisfactory, and the tendency at this time is to discard the practice and to operate each car independently.

Some of the objections to the operation of cars in trains are the following: As both cars must be stopped whenever even one passenger is to be taken on or let off, the aggregate number of stops and the time lost by stops per car is materially increased; the frequency of the cars is decreased; experience has shown that the danger of accidents is increased; one of the cars must stop at a considerable distance from the street crossings, and passengers must get on or off among the teams and other travel on a part of the street which should be kept as clear as possible for vehicles. As the cars are stopped by independent brakes and not coupled together with sufficient firmness they are subject to sudden shocks which are very unpleasant to the passengers.

The last-named objection might be largely overcome by equipping each car with motors and with power brakes, all under control of one motorman, and couplings might be devised that would hold the cars more firmly together, so that there would be no slack, but all the other objections would remain and become more pronounced as the individual cars are made longer. With cars of the size and capacity we have recommended their operation in trains would not only be disadvantageous, but positively objectionable.

POWER BRAKES.

In order to operate the maximum number of cars on a line, a high degree of precision and expedition is requisite, both in accelerating and retarding the movement of the individual cars. In Manhattan the motors and current are usually adequate to secure any reasonable rate of acceleration, although it may be said that the controller apparatus does not usually afford the degree of smoothness in starting that is desirable. Hand brakes are still in general use throughout the city. As it has already been noted that the length of time consumed in stops is the controlling factor in limiting the number of cars that can be safely operated, and hence limits the capacity of the line, it becomes of the utmost importance to determine all the causes affecting this loss of time. Among these is the length of time consumed in bringing the car to rest, and this obviously depends upon the efficiency of the brake employed. It should be noted, also, that, in the rapid retardation required by high speeds and short headways, the comfort of the passengers is seriously affected. It follows, therefore, that while the brakes must be capable of stopping the car very promptly, it must not be so sudden in its action as to discommode the passengers. If too slow, it wastes time; if too quick, it shakes people up. The discomfort to passengers is measured mainly by the maximum resistance of the brake, while efficiency depends mainly on such promptness of application as will permit the car to be brought to rest by a uniform resistance, which is also the condtion of least discomfort to passengers. This points plainly to the power brake as alone fulfilling this requirement. With the hand brake, in order to secure the necessary power from a man's unaided strength, the brake handle must travel a long distance in setting the brake, which consumes much valuable time, and, to make up for this loss of time, the brake must be made to act much more powerfully at the end, with corresponding discomfort to the passengers, to say nothing of the wear and strain on the mechanism. The effect on the motor man should also be considered. It is not merely a severe tax on his physical strength, but on his nerves as well, for knowing that the brake will not act promptly, he will often apply it at the least sign of danger, while at another time his fatigue may lead him to neglect its application when really required. Any one who has observed the ease with which a touch on the power brake handle controls a heavy car, and the severe effort required to accomplish the same result by the hand brake, will need no further argument. The capacity of the line, the safety and comfort of the passengers and the well-being of the motorman would all be enhanced by the substitution of the power brake.

The use of power brakes on surface cars is constantly increasing, and their necessity on all important lines is now generally acknowledged. It will be admitted that in no other city are conditions such as to make their employment more necessary than on the congested streets of Manhattan. We therefore recommend that all cars now in use on the crowded lines be equipped with power brakes as soon as possible, to be followed by their general adoption on all the lines within a reasonable time.

OBSTACLES TO CAR MOVEMENT.

There can be no question that the present conditions of vehicular travel upon the congested streets of New York make it impossible to secure the maximum service which the street car lines would otherwise be capable of rendering. Viewed in this light, the question of regulating vehicular travel on the congested streets becomes one of great importance. The conditions at present on streets occupied by surface roads are found to be as follows:

1. Broadway and most of the other congested streets occupied by double-track surface railroads are generally of such restricted width between curbs that two vehicles cannot stand or pass abreast between the curb and the cars without obstructing the passage of the latter.

2. Vehicles in large numbers stand along the curb for various purposes, or for no other reason than to wait, and every moving vehicle on the same side of the street must, in order to pass these standing vehicles, turn out and go around them, thus obstructing the cars. The committee finds that this practice of permitting vehicles to stand along the curb is a crying abuse and a positive nuisance, which should be vigorously opposed and speedily abated. Were it not so common and so long tolerated it would undoubtedly meet with general protest and opposition. In the downtown district, particularly, trucks and other vehicles seem to be constantly in the habit of standing along the curb when they have nothing else to do. Even when there for a legitimate purpose, such as loading and unloading goods, they occupy far more time than is necessary. It is not unusual to find trucks standing before business houses for from 15 minutes to half an hour, and even longer, waiting an opportunity to load or unload goods, when the actual operation, after it is begun, may require but five minutes, or even less time.

Cabs deliver passengers and deliberately stand along the curb awaiting their return. In the uptown shopping district long strings of carriages wait before the store, often for half an hour and longer, while the owners are shopping inside. In the meantime every moving vehicle must pass around these standing carriages, and in doing so must encroach upon and obstruct the car tracks. These conditions are not sporadic or occasional. They may be seen on Broadway and other shopping streets at almost any hour during the day and on almost every block. On other business streets a similar abuse exists in still more aggravated forms. On West Broadway, for instance, may be seen great numbers of trucks backed against the curb at right angles to the street, so that not only is there no room for other vehicles to pass on the same side, but they actually extend to and obstruct the cars. Our observation disclosed in some cases as many as 18 such vehicles backed against the curb on one side in a single block—a number greater than could stand longitudinally along the curb within the block.

The problem of satisfactorily regulating the vehicular travel, difficult as it must be under the most favorable conditions, is greatly complicated by this nuisance of standing vehicles. This reprehensible practice can only be defended upon the assumption, which seems to be general, that the streets and sidewalks may be occupied as places to carry on other affairs than traveling and transportation—an assumption that has no foundation in justice, nor, we are informed, in law, whenever such occupation interferes with the rights of others.

3. The habit of driving trucks along and upon the rails of street car tracks, when not necessary to avoid vehicles standing along the curb or other obstacles, is very prevalent, and drivers often refuse for long distances to leave the tracks to allow cars to pass.

4. The practice of opening street pavements to construct or repair underground structures during the daytime and leaving the excavations open with barricades around them, sometimes for days, offers a very serious obstruction to travel, compelling vehicles to resort to the car tracks to get around them.

5. The ordinances of the city now allow building material to be unloaded and stored upon the street in front of buildings under construction, and these ordinances are often taken advantage of to very seriously obstruct the street for long periods of time.

6. The enormous travel upon many of the crosstown streets is allowed to engorge the intersections and thus very greatly delay the passage of vehicles and street car on the main lines of travel.

REMEDIES.

The most serious cause of obstruction and delay—the standing of vehicles along the curbs of congested streets—should be abated by the enforcement of existing ordinances, which seem to be ample for the purpose. If, as the committee believes, the proper regulation of vehicular travel would permit an increase of over 20% in the street car service on the crowded streets, such regulation becomes a matter of so much importance to the public as to justify the immediate and stringent enforcement of the ordinances necessary to bring about such result. After a careful study of the subject in the light of the data collected we have formulated a brief code of rules for the regulation of vehicular travel upon the streets, a copy of which is attached hereto. These rules were adopted after the committee had had a number of conferences with Capt. A. R. Piper, Deputy Commissioner of Police, who was at the time engaged upon a similar study of the regulation of street travel, and we are glad to be able to say that these conferences resulted in a substantial agreement of views in reference to the matter contained in these rules. We have not undertaken, it will be observed, to formulate a complete code of "Rules of the Road," our object being to embrace only those features which affect the street car movement on the congested streets.

RULES FOR THE REGULATION OF VEHICULAR AND SURFACE CAR TRAVEL UPON STREETS.

1. The word vehicle as used herein shall include everything on wheels or runners, except street cars and baby carriages. Horses or other animals led or driven through the streets must, so far as possible, conform to the rules prescribed for vehicles.

2. Vehicles shall keep to the right and as near to the right-hand curb as possible. Vehicles meeting shall pass each other to the right. Vehicles overtaking other shall, in passing them, keep to the left. A vehicle turning to the right into another street shall keep to the curb in making the turn. A vehicle turning to the left into another street shall pass to the right of the center of the street intersection and thence to the right-hand curb of the street turned into. No vehicles shall stop with its left side to the curb at which the stop is made. If necessary to cross a street in order to stop at a point on the opposite or left-hand curb, a vehicle shall continue beyond such point to a sufficient distance, shall cross the street as nearly as possible at right angles and return to the desired point in the same direction as the travel on that side of the street.

Vihicles shall not be driven or propelled at a speed exceeding eight miles per hour, and they must be restricted to lower speeds wherever necessary to prevent accident or injury to persons or property.

Vehicles must approach all street crossings with speed under such control that accidents may be avoided. No turn shall be made in a street at a speed exceeding four miles per hour.

3. No vehicles shall stand on any street between the hours of 8 a. m. and 7 p. m. upon which electric cars are operated at regular intervals of three minutes or less each way, except while actually engaged in taking on or discharging passengers or while actually engaged in loading or unloading merchandise, unless the street at the point of stopping is of such width as to leave a clear space of at least ten feet between the standing vehicles and the nearest rail of a car track.

4. For taking on or letting off passengers and for loading and unloading merchandise between the hours of 7 a. m. and 8 p. m. upon streets having car tracks, over which cars are regularly operated at intervals of three minutes or less in each directions, the following periods of time, and no more, during which vehicles may stand on such streets shall be allowed, viz.:

	Minutes.
For loading and unloading passengers.....	2
For loading and unloading merchandise such time only as may be necessary not to exceed.....	5

No vehicle shall stop to load or unload merchandise or freight on any such street in front of any business house or residence which has a side or rear entrance on another street upon which electric cars are not operated, without a permit from the Police Department.

5. When stopping for any purpose on any street between the hours of 8 a. m. to 7 p. m. vehicles shall stand parallel with and as near to the right-hand curb as possible, with the front of the vehicles in the direction of the movement of travel on that side of the street, provided that vehicles may stand against and at right angles to the curb, where at least 10 ft. will thereby be left clear between such standing vehicle and the nearest car tracks, or, where there be no car tracks, two vehicles may meet or pass abreast on the unobstructed part of the street.

No vehicle shall stand upon any street for any purpose in such a position as to obstruct the car tracks and prevent the free operation of cars thereon.

The words "stop" and "stand" as used herein shall not apply to stops caused by accidents, or by unavoidable unobstruction or by other causes over which the owner or driver of the vehicle has no control.

Upon streets having more than one railroad track no vehicle shall be driven upon any track regularly used for cars going in an opposite parallel direction, except for the purpose of crossing such track.

6. Except when forced to do so by standing vehicles or by other obstructions, no vehicle shall travel upon or so near to any car tracks as to obstruct cars moving in the same direction. And vehicles shall leave the track at the first opportunity, so that cars may pass them. The intent of this article is that no vehicle shall obstruct the regular movement of any car moving in the same direction as the vehicle, except where it is absolutely necessary to do so in order that the vehicle may proceed along the street.

7. The officers and men of the Fire Department and Fire Patrol, with their fire aparatus of all kinds, when going to, on duty at, or returning from, a fire, and all ambulances and the officers and men and vehicles of the Police Department and all physicians having permits from the Police Department shall have the right of way in any street and through any procession except over vehicles carrying the United States mail.

8. At street crossings cars or vehicles moving north or south shall have the right of way over all others, except as above mentioned, whenever the front end of the north or south-bound car or vehicle shall reach the house line at the same time or before any part of an east or west-bound car or vehicle, or the horses of the latter, shall reach the house line, unless otherwise directed by a police officer.

The most important provisions of the rules submitted by us are designed to prevent the unnecessary standing of

vehicles in the streets, thus obstructing other travel, and to prevent slow-moving vehicles from occupying the street railway tracks, and thus delaying the movement of cars. The requirement that vehicles shall not be allowed to stand upon the congested streets when not actually engaged in loading or unloading freight or passengers is so reasonable that no serious objection should be raised against it. In nearly every part of the city there are numerous cross and side streets that are comparatively uncrowded, and these can and should be made use of by the vehicles that now stop and wait on the congested streets. At the entrance of most of the hotels, theatres and large retail stores employees are stationed who could readily call the carriage of patrons when they are wanted, so that little inconvenience need result.

The most serious and difficult problem is the proper regulation of trucks and delivery wagons that stop to load and unload in front of business houses. The great majority of business houses are so located that they have no entrance except from the front, and to prohibit loading and unloading at their front entrances would be practically to force the occupants out of business. While it is not, therefore, possible to prohibit vehicles from standing on the crowded streets to load and unload, there can be no doubt that the privilege is now very greatly abused and that the resulting obstruction can be greatly diminished. It is certainly fair and reasonable that vehicles should not be allowed to stand upon these streets for any longer than is absolutely necessary to take on or discharge their loads, nor is it unreasonable to require that both teamsters and business houses should adopt means to expedite the operation as much as possible. Observations will convince any one that little effort is now made to do so. On the contrary, many owners and occupants of buildings seem to consider that they practically own the street in front of their premises, and may occupy it for any time or to any extent that suits their pleasure. They should be made to realize that the whole of the street, including the sidewalk, belongs to the public at large, that streets are primarily for the purposes of travel and transportation, and are not places in which to transact other business. Legally, a street cannot be appropriated by any one person for any purpose other than actual travel if such use becomes a nuisance to other individuals or to the public at large. If this rule were kept in mind by business men, and enforced by the municipality, a vast improvement in present conditions would result, without seriously interfering with the proper transaction of business. There are numerous places in the city where a single business house practically monopolizes one-half of the street in front of it. The time is sure to come in Manhattan when it will be necessary to enforce the rights of the public in such cases, and to compel the offending business houses to provide space for loading and unloading their merchandise elsewhere than on the streets.

It is remarkable that while great advances have been made by business men in almost every other direction, the handling of merchandise from street to storehouse is still done as it was centries ago. Little or no attempt has been made to expedite or economize the process of mechanical appliances. There can be no reasonable doubt of the possibility of employing such appliances for rapidly and cheaply handling parcels, both large and small, between the truck and the store entrance, as well as distributing them throughout the building where required, as is now done in many large manufacturing establishments. For the purpose of loading and unloading the trucks some of the numerous forms of crane, or overhead tramway, can be utilized, and the power to operate them may be either steam, hydraulic, compressed air or electricity, as may be most convenient in each case. It is almost certain that the use of such appliances would result not only in a material saving of time, but in such greater economy of handling as would soon repay the cost of the apparatus. The committee calls particular attention to this matter in the hope that it may be the means of helping to abate the nuisance of standing vehicles on the streets, without in any way adding to the inconvenience or expense of conducting business.

The occupation of the car tracks, or the driving so near them as to obstruct the free movement of cars, by vehicles moving at a speed lower than that of the cars, should be strictly prohibited, except where the vehicles are forced upon the track by other standing or slower-moving vehicles or by other obstructions. Vehicles on or so near the tracks as to delay the movement of cars should move out of the way as soon as possible after the driver is signaled to do so by the motorman.

The rules for controlling travel should be strictly enforced by the police, and offenders should be fined or otherwise punished for each offence. Much of the delay to the movement of cars at the present time is due to disregard to these rules, and their enforcement would result in a very considerable improvement in the car service without detriment to the vehicular travel as a whole.

Wherever it is at all possible, the work of cleaning manholes and of constructing or repairing underground works should, on all congested streets, be done during the night. While the cost of the work might be thus sometimes increased, the benefit resulting to the traveling public would fully warrant its requirement.

The ordinances relating to the erection of buildings and the occupation of the street with building material should be so amended as to prohibit the obstruction of congested streets, except under circumstances where it is impossible to avoid it. In the great majority of cases, all building material can be stored in or upon the site of the new building, or on platforms over the sidewalk, without serious expense or inconvenience to the builders. At present, materials to be used in the construction, as well as waste material to be hauled away, are often allowed to remain for several days, and sometimes for weeks, in such positions as to practically cut off the use of nearly one-half the street, to the very serious inconvenience and loss of time to street travel and street cars. Such misuse of the crowded streets should be prohibited.

Broken-down vehicles that are not promptly removed from the streets are often the cause of serious obstruction. Some system should be devised and enforced that will insure their removal as quickly as possible. If a fine were imposed upon owners who allowed broken-down vehicles to remain on the street longer than one hour it would have a salutary effect.

The delays caused by interfering currents of travel at street crossings cannot be wholly avoided, but a proper regulation of vehicles at these street intersections would considerably decrease the present inconvenience and loss of time occasioned thereby. The Police Department has recently taken this matter in hand, and the careful study of conditions, and the vigorous application of systematic regulation which the Deputy Commissioner is applying to this and other needed reforms, promise very material improvement. The matter may safely be left in the hands of the Police Department.

The use of heavy, slow-moving trucks on the present over-crowded streets having car lines upon them should be discouraged, and, as far as practicable, prevented. In many cases the nearby parallel streets could be used by these trucks without inconvenience or loss of time. To encourage the use of such side streets they should be well paved, and, as far as possible, cleared of obstructions to vehicular travel. The unused car tracks on a number of these streets are serious obstructions to vehicular travel, and they should be removed as soon as possible. More will be said upon this point under the head of "Unused Car Tracks."

The congestion now so common at certain street intersections could be reduced, and the movement of both vehicles and cars greatly expedited, if teamsters would avoid these particular intersections, as they might often do, not only without any serious inconvenience, but with positive advantage and actual saving of time, since the delays at these places often extend over several minutes. The intersection of Fulton St. with Greenwich St., where the congestion is often very great, resulting in frequent delays both to trucks and cars, is a notable example.

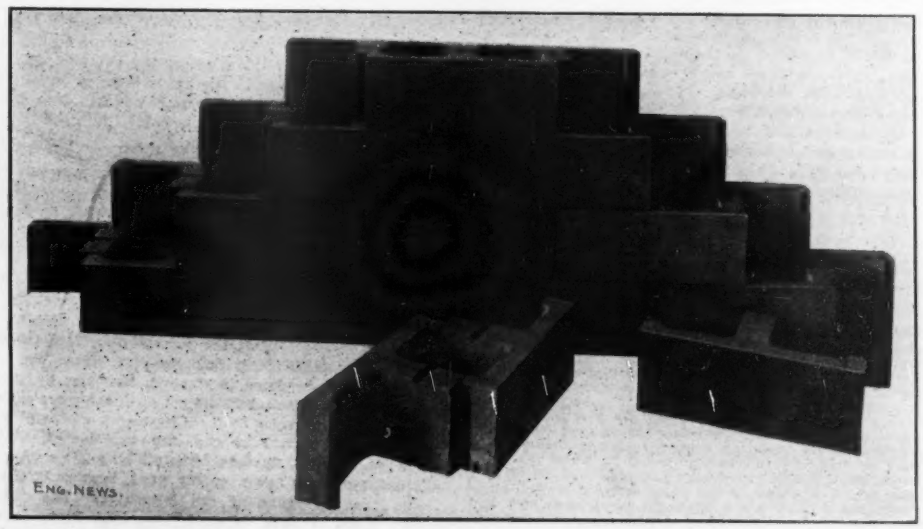
CONCRETE BLOCKS FOR BUILDINGS.

The use of concrete blocks for architectural construction work is extending to a marked degree, and several systems of construction of this kind are in use. In some cases the concrete blocks are used only for trimmings and decorative work, such as cornices, window sills and lintels, etc., where the walls are of brick. In other cases, however, they are used also for the walls, while concrete slabs or tiles form the roof covering.

Walls built of concrete blocks are usually hollow and may be of "one-piece" or "two-piece" construction. In the former case, each block is hollow and its width is equal to the thickness of the wall. In the latter case, the blocks are approximately of T-shape in plan, set on edge, so that two blocks form the inner and outer faces of the wall, their ribs or flanges serving as distance pieces or cross bonds in the space between, these ribs being 12 ins. apart. This two-piece construction is claimed to give a greater proportion of open space and less weight of material, while owing to the separation of the inner and outer faces moisture cannot penetrate. The accompanying cut shows a portion of a wall built on this system; it also shows a single block on the right, and in the middle are two blocks put together. The numerous patents covering this system are owned by the American Hydraulic Stone Co., Century Building, Denver, Colo.; Mr. J. A. Ferguson is President, and Mr. F. E. Kidder,* is Consulting Engineer of the company.

The wall blocks are usually 9 × 24 ins. on the face, and the depth of ribs depends upon the thickness of wall required. They may also be made of special sizes. The regular blocks weigh 38 lbs. each, and a wall built with them contains 52% open space, the cross bonds being 12 ins. apart. The blocks for corners, door and window openings, sills, caps, belt and weather courses can be made of any desired shape or pattern. Each block is made in a mold under hydraulic pressure of 30 to 35 tons for a wall block 9 × 24 ins. In this way the block is made very dense and strong. The pressure is applied to the face of the block. The crushing strength is about 1,600 lbs. per sq. in., and the lateral strength is considerable. Tests of 21-day blocks, 24 × 12 ins. (set on edge), at the Allis-Chalmers works in Milwaukee, gave crushing strengths of 2,200 to 2,600 lbs. per sq. in. The concrete for the body of the block is composed of 1 part cement to 6 or 8 parts of ¾-in. gravel or crushed stone, with sufficient fine material to fill the voids. If a special facing is desired for the exterior of the building, about ¼-in. of concrete is raked off and the space filled with the facing concrete. For a granite face, this may be composed of 1 part cement (light in color) and 3 parts crushed granite. The pressing board for the face may be smooth, to represent sawed or hand-dressed stone; or it may be so shaped as to represent rock-faced, bush-hammered or other style of facing. When taken from the press, the blocks are stacked up for ten days, and are kept moist by spray from overhead sprinklers.

The hollow air space, divided by partitions, makes the building cool in summer and warm in winter; and the spaces can be utilized for heating and ventilating flues, electric wires, plumbing pipes, etc. Among the buildings erected is the Angelus Hotel, at El Paso, Tex.; this is a four-story building, with 9-in. blocks above the first story. The blocks for this were made by inexperienced laborers. Mr. Kidder reports that a 10-



CONCRETE BLOCKS FOR BUILDING CONSTRUCTION.

*Author of "Architects' and Builders' Pocket-Book" and "Building Construction and Superintendence."

in. wall will have sufficient strength for a three-story building of ordinary construction. For taller buildings, or for heavy construction, the walls of the lower stories could be increased to 12 or 14 ins. in thickness, or a 10-in. wall could be used having some of the hollow spaces filled with concrete to form piers. For partitions, 4-in. to 8-in. walls would answer.

There are three styles of machines used for making the blocks. One is a portable hydraulic hand-press, designed especially for out of the way places, for construction of mills, etc., at a distance from the railway. This will turn out (with five men) 400 blocks per day, being all hand labor and each block being 24 × 9 ins., or 12 × 9 ins., as may be desired. Another is a hydraulic power press, the capacity of which is 1,000 blocks per day. This is operated by an electric motor or small gasoline engine to be used in connection with a power concrete mixer; six men are required to handle this product. The third is a very heavy hydraulic press, giving 35 tons' pressure to each block, producing 1,500 blocks per day with eight men. A 10-HP. engine or motor operates the press and the concrete mixer. The latter product is equivalent, taking the place of 13-in. brick wall construction, to 32,000 brick per day, and, taking the place of 17-in. brick wall construction, is equivalent to 43,000 brick per day. Two masons and a helper can lay 400 bricks in a day.

As to the cost of the work, we quote the following statement made by Mr. Kidder:

I made a test of the cost of hydraulic stone on March 2, 1903, the factory being under my control. Five men and one press were used, all material being carefully measured and weighed. The test was made on faced blocks for a 10-in. wall, 1 part cement to 6 parts sand and gravel with a 1 to 2 face, run through a fine sieve, the blocks being 8¾ × 23¾ ins., 12 blocks per sq. yd. of wall. Using the data obtained from this trial, the time and material required in making the blocks, per sq. yd. of wall, averaged as follows: Labor, equivalent of 1 man, 1 hr. 15 mins; cement, 0.78 sack; gravel, 4 cu. ft.

Figuring labor at $2 per day of 10 hrs., gravel at 75 cts. per load of 1¼ yds., and cement at $2.50 per bbl. (four sacks to the barrel), the cost per sq. yd. was 84 cts. Allowing 48 cts. per sq. yd. for laying and mortar, 10 cts. per sq. yd. for hauling (12 blocks), makes a total of $1.42 per sq. yd. of completed wall, or 15 7-9 cts. per sq. ft. of 10-in. wall. In comparison with the cost of a common brick wall with a pressed-brick face, figuring brick at $12.50 per 1,000 in the wall and adding the cost of pressed brick for facing at an average cost of $30 per 1,000, and making no allowance for cut-stone trimmings, a 9-in. wall will cost 39¾ cts. per sq. ft. of wall, or $3.57 per sq. yd.; for a 13-in. wall, 49 cts per sq. ft. or $4.41 per sq. yd.; and for a 17-in. wall, 58½ cts. per sq. ft. or $5.26 per sq. yd.

As to the additional cost of making a wall in colors, I have no information, except as to reds and browns, which cost 1.8 cts. per lb., making the additional cost approximately 10 cts. per sq. yd. of wall.

It should be stated, in considering the future of this product, that the above test was made entirely by hand labor and hand machines. Automatic machines with power mixers and feed would greatly reduce the cost. As far as the strength of the wall is concerned, I do not hesitate to say that it has ample strength for any building, provided the walls are of proper thickness. A 10-in. wall would satisfactorily take the place of a 13-in. or 17-in. brick wall.

IRRIGATION ENGINEERING WORK under the National Irrigation Act was referred to as follows by President Roosevelt in a letter read at the opening of the National Irrigation Congress on Sept. 15:

Some of the projects which promised well at first are found on careful study to be impracticable, either because of scanty water supply or of great cost; others must await higher values in land, while still others stand the test and are ready for immediate construction. The feasible projects always are large and costly, because private enterprise already has seized upon the smaller and less expensive ones, leaving to the Government the great works which are to be an essential part in bringing the Nation to its full development. Great care and the highest engineering skill are required to plan and build such works, which are among the most difficult undertakings of mankind. They must be built for permanence and safety, for they are to last and spread prosperity for centuries.

To design and build such works a body of engineers of the highest character have been brought together in the reclamation service, for only men impartially selected for capacity alone are capable of creating these great structures. Merit must govern, not only in the selection of men, but still more in the selection of the projects. Every reclamation project selected for construction must possess the qualities which commend it as a National undertaking, certain to reclaim large tracts of arid land and to support in well-being a dense and vigorous population.

The President devoted the concluding portion of his letter to emphasizing the necessity of forest preservation in the West, and urged that the Government Forest Reserve policy should receive the hearty support of all interested in irrigation.

THE GOVERNMENT IRRIGATION FUND has been greatly increased by the public land sales of the year 1903. The fund shows an aggregate of $16,191,836 derived from land sales during 1901, 1902, and 1903, of which $8,461,494 has come from the sales in 1903. In expending this vast sum of money each state will receive its share in proportion to the public land sales in that state.

The total amount received in 1901 was $3,144,822, and in 1902, $4,585,521. The receipts by states in 1903, approximately, follow:

Arizona, $43,832; California, $783,849; Colorado, $510,072; Idaho, $642,219; Kansas, $18,417; Montana, $352,168; Nebraska, $118,839; Nevada, $12,465; New Mexico, $150,128; North Dakota, $1,228,844; Oklahoma, $816,087; Oregon, $1,884,730; South Dakota, $239,421; Utah, $87,520; Washington, $1,099,980; Wyoming, $272,924.

THE CONCRETE WATER SUPPLY CONDUIT at Los Angeles, Cal., described in our issue of Aug. 27, 1903, is being built by the day. The concrete is mixed by hand, partly on account of the difficulty of moving a mixer along the line of the conduit, which is meandering, and on very steep hillsides. Mr. Wm. Mullholland, Superintendent of the Los Angeles water-works, informs us that the cost is within the estimate of $5 per lin. ft. complete.

A PACKAGE FREIGHT TRAFFIC is to be conducted on the extensive tunnel system of the Illinois Telephone & Telegraph Co., of Chicago, Ill. This system of tunnels was fully described in our issue of Feb. 19, 1903. According to the newspaper accounts 50 motor cars and 1,500 freight cars, contracts for which have already been awarded, will be constructed, and will be operated by an overhead trolley system over 56-lb. steel rail tracks. This equipment will be installed not later than July 1, 1904. The tunnels will be connected with the 38 freight yards near the business center of the city, and with every power plant, manufacturing establishment and office building within the two square miles of territory covered by the 20 miles of tracks. Each car will have a capacity of 6 tons, and it is estimated that the plant will be able to transfer 100,000 tons daily, which equals the total tonnage carted through the downtown streets on trucks at the present time. The tunnels are 6 ft. wide and 7 ft. high—dimensions sufficient to accommodate almost any box used in packing freight. Bulky shipments, such as furniture, for example, cannot of course be accommodated. A "belt and bucket" equipment, such as is used in grain elevators, will be the means of transferring the shipments to and from the underground cars. These plans, together with those for the extension of the telephone system, contemplate an expenditure of $20,000,000. The work as it stands to-day has cost $5,000,000. Contracts have also been let for the construction of an exchange of 100,000 telephones, outside of the 10,000 in the "business men's" exchange, which were all that was included in the first announcements.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a butting collision which occurred on the Baltimore & Ohio Ry. at Cambridge, O., on Sept. 11. Two freight trains collided in the yards because of failure to give proper signals, and one man was killed in the resulting wreck.

FIFTEEN CASES OF DYNAMITE EXPLODED in a car at the Michigan Central yards in Bay City, Mich., Sept. 13, while a switching crew was making up a train. Two men were killed, three were seriously injured, 400 houses in the neighborhood were damaged, and 25 freight cars were wrecked.

THE 15,000-TON CRUISER "MARYLAND" was launched on Sept. 12 at the yard of the Newport News Shipbuilding & Drydock Co., Newport News, Va. The launching was rendered incomplete, however, by an unusual accident. The vessel did not clear the ways entirely, but stopped when some 60 ft. of its length was still on the ways. Three days later the ship was floated, without further accident or damage. The sticking is attributed to the melting of the tallow on the ways, because of the hot weather at the time of the launching. The "Maryland" is 502 ft. long on water line, 69½ ft. in extreme breadth, and 24 ft. 1 in. in normal draft. It is to have a speed of 22 knots, the engines being of 23,000 HP. The coal capacity of the vessel is 1,850 tons, and the full complement of men and officers is about 830. The vessel is armored with a 9-ft. belt, full length, 6 ins. thick in the main portion; the turret armor is 6½ ins. and 6 ins. There are to be four 8-in. rifles in two turrets (fore and aft), and fourteen 6-in. rapid-fire guns. The secondary battery is to contain eighteen 3-in. guns and twelve 3-pounders, besides a number of smaller rifles.

A PLATE MILL with rolls 152 ins. in length has just been completed at the Contesville, Pa., works of the Worth Bros. Co. This is said to be the largest set of plate rolls in the United States. Its owners announce that they are prepared to furnish plates 12 ft. in width in thicknesses of ½-in. to ⅞-in. The company's works have a capacity of 4,500 to 5,000 tons of plates per week.

COMPRESSED-AIR POWER is being introduced on a large scale at Norwich, Conn. The hydraulic air-compressing plant on the Quinebaug River, three miles above Norwich (described in Engineering News of June 12, 1902), supplies air at 80 to 90 lbs. pressure, which is piped to the City of Norwich, and is there distributed by street mains. Quite a number of factories and shops are now using this air in their steam engines in place of steam, with satisfactory results, it is stated. Reheating the air before it goes to the engine is practised by some of the users. A provisional price of $50 per HP. per year has been fixed by the company supplying the air.

A NOVEL SWIMMING TANK has been made at the works of the Tucker & Dorsey Mfg. Co., at Indianapolis, by utilizing the fire cistern of the works. The cistern is a circular reservoir 41 ft. in diameter, with concrete bottom, fed from a deep well and utilized also to supply the boilers, so that the water is constantly changing. The only alteration necessary was to put in a false wooden bottom and steam pipes for heating the water. A dressing-room and shower baths have also been provided for the convenience of employees using the tank.

THE BOLL WEEVIL COMMISSION of Texas has reported to the Governor that of the 162 claimants for the $50,000 reward, for a means to exterminate the boll weevil, none has fulfilled the requirements of the law. The commissioners are of the opinion, however, that a means of exterminating the pest will ultimately be found.

THE POWER OF THE VICTORIA FALLS on the Zambesi River, in South Africa, is to be developed by the African Concessions Syndicate. The height of the cataract is over 400 ft., and the volume of the stream is sufficient to make the available power rival Niagara. The railway extension from Bulawayo has reached a point within 70 miles of the falls and is expected to reach there next spring. The principal use of the power when developed would be for long distance transmission to mining districts, and for railway purposes.

EXPERIMENTS ON THE STORAGE OF COAL made at the Alexandria Docks, England, have shown that coal loses very little of its heat value if stored under water, while if stored in air a loss of 10% in a year or so is not uncommon. The proposition is made, therefore, that at naval coaling stations the coal should be stored in concrete reservoirs.

RAILWAY TRAIN ACCIDENTS in Great Britain and Ireland caused the death of only five passengers in 1902, four of which occurred in one accident.

A SEWERAGE SYSTEM is to be built at Johannesburg, South Africa, to replace the "pail system" hitherto used. The separate system is to be used, and it is proposed to build all main sewers larger than about 2 ft. diameter of concrete-steel. The total cost of the system, including necessary provision for storm water drainage, is estimated at about $3,200,000.

A LARGE STONE ARCH BRIDGE has been constructed at Morbegno, Italy, over the River Adda. The bridge is in a single span, 70 m. (230 ft.) between inner faces of abutments. Its rise is 10 m., or one-seventh of the span. In profile the intrados is three-centered, with a radius of 75 m. in the central portion and about 51 m. in the side portions. The arch-ring is 1.5 m. (4.9 ft.) thick at the crown, and 2.2 m. (7.2 ft.) at the springing lines; it is constructed of granite ashlar. The width of the arch is 5 m., the roadway 6.1 m. over balustrades; the sides are battered 1 in 20. Over the haunches are three relieving arches on each side of the center, each a semicircular arch of 4.5 m. (14.8 ft.) clear span. The main arch ring is designed to have the line of pressure for dead load lie in the center of the ring, and to secure this condition three hinge-joints were provided, one set at the crown and one near each springing line, about 5 ft. from the skewback. These hinges were filled up solid with masonry after the entire bridge was completed. The bridge is on the line of the railway from Colico to Sondrio. It was begun in February, 1902, and completed during the past summer.